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Undocumented migrants' access to and demand for COVID-19 vaccination during the early phase of the vaccination campaign in four high-income countries

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Abstract

Study objectives:
The marginalization of undocumented migrants raises concerns about equitable access to COVID-19 vaccination. This study aims to describe migrants' perceived accessibility to and demand for COVID-19 vaccination during the early phase of the vaccination campaign.

Setting:
This multi-centric cross-sectional survey was conducted in health facilities providing care to undocumented migrants in the United States, Switzerland, Italy, and France in February-May 2021. l

Participants:
Eligibility criteria included age >16, being of foreign origin and living without valid residency permit in the country of recruitment. A convenience sample of minimum 100 patients per study site was targeted.

Primary and secondary outcome measures:
Data was collected using an anonymous structured questionnaire. The two primary outcomes were perceived access to the local COVID-19 vaccination program and the demand for vaccination.

Results:
In total, 812 undocumented migrants completed the survey (54·3% Geneva, 17·5% Baltimore, 15·5% Milano and 12·7% Paris). In total, 60·9% were women and the median age was 40 years old (range 17-76). Participants originated from the Americas (55·9%), Africa (12·7%), Western Pacific (11·2%,) Eastern Mediterranean (7·9%,), Europe (7·6%) and South-East Asia (4·7%). Overall, 14·1% and 26·2% of participants, respectively, reported prior COVID-19 infection and fear of developing severe COVID-19 infection. Risk factors for severe infection were frequently reported (29·5%). Self-perceived accessibility of COVID-19 vaccination was high (86·4%), yet demand was low (41·1%) correlating with age, co-morbidity, and views on vaccination which were better for vaccination in general (77·3%) than vaccination against COVID-19 (56·5%) Participants mainly searched for information about vaccination in the traditional and social media.

Conclusions:
Public health interventions using different channels of information should build on trust to the accessibility of COVID-19 vaccination programs and positive perception about vaccination in general to enhance undocumented migrants' demands for COVID-19 vaccination.

Trial registration: no registration

Strengths and limitations

- The study included undocumented migrants, a hard to reach population, in five countries
- Efforts were made to overcome language, trust and literacy barriers to participate
- The number of participants differed in every study sites

Introduction

It is estimated that between 3.9 and 4.8 million undocumented migrants live in Europe and 10.5 million in the United States (US).[1-3] Economic opportunities, integration policies, and the rights and benefits

afforded to undocumented migrants vary by host country. However, challenges including language barriers, fear of deportation, poverty, housing precariousness, and limited access to healthcare and workplace protections, are common experiences for most undocumented migrants.

Although undocumented migrants represent less than 1% of Europe's and 3.2% of the US total population, emerging evidence points to the devastating impact of COVID-19 in this group. In high-income countries, migrants have high risk of COVID-19 infection, morbidity, and mortality.[4] Although COVID-19 outcomes by specific immigration status are rarely available, surrogate markers (e.g. language, country of origin, housing status, health insurance eligibility, and demographics) suggest that undocumented migrants are at particularly high risk.[4-13] Community and health facility-based studies in Europe and the US showed exceptionally high SARS-CoV-2 positivity rates among foreign-born or limited English proficiency patients.[7,8,14,15] In the US, COVID-19 case rates were highest in counties with large immigrant communities, and the correlation was stronger in areas with more Central Americans, a group with high poverty levels and irregular migrant status .[1,12,16] In addition, there is evidence of poor outcomes due to delayed presentation to care among undocumented migrants.[4,6,10,17,18] Mortality data by migrant status is limited, but what is available shows that compared to native-born citizens, migrants to Europe and the US, particularly those from low and middle-income countries, have higher excess all-cause and COVID-19 mortality. [19-23]

Undocumented migrants play an essential role in the global economy but rely heavily on informal and low-wage labor with limited occupational protections. Mitigation strategies to reduce the social, economic and health impact of the COVID-19 pandemic frequently exclude undocumented migrants. Without a social safety net, many continued to work at the peak of the pandemic in high-risk essential jobs, such as logistics, manufacturing, domestic and care activities, construction, and the food processing industry.[11,24,25] Several European countries provided food assistance to migrants during lockdown, and a few further extended benefits. For example, Ireland implemented a system to pay unemployment benefits to undocumented migrants who lost their jobs, and Portugal granted temporary citizenship rights to migrants.[26] The suspension of exclusionary immigrant policies, however, was not uniform and there were many unmet needs and many vulnerable undocumented migrants fell into extreme poverty.[26] A survey conducted in Switzerland in April 2020 showed that almost one in six migrants had experienced hunger during the first lockdown.[27]

Furthermore, long-standing anti-immigrant policies and mistrust of governmental institutions have not been eased during the pandemic, and pre-existing legal, socio-economic, and linguistic barriers to social and health services have exacerbated the impact of COVID-19 among undocumented migrants. [28,29] Although countries deployed health services for COVID-19 without eligibility restrictions based on migration status, no specific measure has been implemented to facilitate access for undocumented migrants who already tended to underutilize social and health services even before the pandemic.[30,31] As a result, pre-existing barriers to accessing health and social services are exacerbated by the pandemic and likely lead to delaying life-saving care for many.[6,10,11,27]

The rapid development of effective COVID-19 vaccines was an unprecedented scientific achievement, but equitable vaccine distribution is a major challenge worldwide. Undocumented migrants and other vulnerable populations have faced significant hurdles to get vaccinated, including digital, transportation, and health system navigation barriers. The European Centre for Disease Prevention and Control (ECDC) and the Council of Europe have called for tailored vaccination programs for undocumented migrants that are free from immigration control enforcement activities,[32] but only a few national immunization plans explicitly include provisions for undocumented migrants, or address potential barriers, such as langauge

proficiency or identification requirements.[33,34] In addition, the willingness of individuals, including undocumented migrants, to get immunized depends on a variety of factors, such as self-perceived risk and severity of illness; confidence in the safety and effectiveness of the vaccine; trust in medical, govermental, or pharmaceutical institutions; behavioral and social processes (e.g. awareness, information, education, social norms, networks, and media). The objective of this multi-centric study conducted in the early phase of COVID-19 immunization programs was to explore undocumented migrants' perceptions of COVID-19 vaccine accessibility and demand.

Methods

Design

This multi-centric cross-sectional survey was conducted in four facilities providing medical care to undocumented migrants in Switzerland, the United States, Italy, and France during the early phase of the vaccination campaign (February to May 2021).

Setting

Geneva, Switzerland

Geneva (population 500,000) hosts an estimated 10,000 to 15,000 undocumented migrants, predominantly women from Latin America, the Philippines and South-Eastern Europe who are active in the domestic and care industry.[35] While potentially eligible to purchasing the mandatory health insurance to access to medical care, less than 10% are actually insured because of financial and administrative barriers. The Geneva University Hospital acts as the main port of entry into the healthcare system for undocumented migrants and other underserved groups of population, providing the full range of preventive, curative and rehabilitation health services.[36] While the Swiss Federal Government has decided upon the universal access to COVID-19 vaccination to all residents irrespective of their legal status in early 2021, the policy implementation has been delayed at Canton level and Geneva was the first Canton to officially integrate undocumented migrants into the vaccination program in May 2021.[37]

Milan, Italy

According to available estimates, there are currently 517,000 undocumented migrants in Italy.[38] Disaggregated estimates at city level including for Milan are not readily available. However, Milan is the economic center and the most populous region in Italy, hence likely to host a large population of undocumented migrants. In principle, the National Health Service system is based on a universalistic model providing healthcare free of charge at the point-of-use against payment of standard flat fees with waivers based on socio-economic criteria and is decentralized at regional level for both policy and service delivery aspects. Access to the NHS requires a valid health card, which is issued based on residency status. As a result, undocumented migrants do not have access to the NHS. To address this fundamental legal and administrative barrier, the NHS provides a temporary access code, which allows access to emergency care and essential services including maternity and vaccination services. In practice, undocumented migrants face barriers even to obtain a temporary access code and rely on charities for accessing healthcare. Among them, ''Opera San Francesco per i Poveri'' is a faith-based charity operating a large size health clinic in Milan providing free-of-charge outpatient healthcare including consultations, diagnostics, and therapy for vulnerable population groups including undocumented migrants. For COVID-

19 vaccination, the NHS procures and distributes vaccines and consumables, while the regional health system administers them through a client-initiated online booking system requiring a valid health card. As of 25th June 2021, the Lombardy Region, with Milan as the chief lieu, granted eligibility for online booking to undocumented migrants with a temporary access code. Charities have mobilized to provide individual support to facilitate administrative, linguistic and practicality challenges.

Baltimore, USA

Baltimore City is an emergent destination for migrants from Latin America.[39] An estimated 20,000 foreign-born Latin Americans live in the city and approximately 13,500 (67%) are not citizens. Migrants from Mexico and Central America have higher non-citizen status (> 80%), low educational attainment (50% with less than high school education), and high rates (70%) of limited English proficiency.[40] In the US, the COVID-19 vaccine is freely available to all, regardless of immigration or insurance status, and the Department of Homeland Security has explicitly stated that immigration enforcement activities will not be conducted at vaccination site.[41] In the early stages of the COVID-19 immunization program, the state of Maryland implemented a phased distribution plan and the vaccine was not available to the general population until April 27, after data collection for this study was completed. The Access Program, Johns Hopkins Medicine in Baltimore, Maryland (TAP) acts as the main port of entry into the Johns Hopkins Health System. Patients are enrolled in TAP if they are low income (<200% federal poverty line) and are ineligible to enroll in Medicaid or subsidized health insurance because of their irregular immigration status.

Paris, France

Avicenne University hospital is located in the Department of Seine Saint Denis in the North-East of Paris. The Department is historically a place where migrants use to be provided social lodging after the Second World War (mainly Sub-Saharan Africa and North-African communities). It is estimated that more than 30% of the population is constituted of immigrants, with recently an additional wave of migrants from South Asia. Moreover, the majority of undocumented migrants in metropolitan France (around 400.000) tend to be concentrated in this Department. Undocumented migrants in France have access to health via State Medical Aid, an insurance coverage for individuals with no right to National Health Insurance. Those without any coverage may access health care via specific units created for uninsured persons (PASS, Permanence d'accès aux soins), located in hospitals principally. Avicenne University Hospital receives uninsured persons via this unit on a daily basis. In France, all eligible persons are entitled to Covid19 vaccination, as per government declaration.

Participants

Eligibility criteria were age equal or above 16 and living as a foreigner without valid residency permit (undocumented) in the country of recruitment. Participants were recruited upon spontaneous presentation (walk-in) to one of the participating health facilities.

We used several strategies to reduce the risk of recruitment and measurement bias by addressing the main barriers limiting undocumented migrants' participations in health programs such as fear of personal data misuse and socio-cultural factors. All consecutive patients consulting at the four health facilities were informed about the study orally and with written material in different languages. We explained that the questionnaire was anonymous, and that no identifying information was collected considering the

frequent fear of undocumented migrants to disclose personal information. The questionnaire was translated in French, Spanish, Italian, Portuguese, Arabic, English, Tagalog, Albanian, Ukrainian, and Russian to match with the main languages spoken by migrants visiting the participating health facilities. Participants were proposed the support of research assistants competent in various languages to fill the questionnaire to overcome potential difficulties in reading and understanding the questions.

Data source and variables

We designed a 15-item questionnaire (Supplementary material) based on UNICEF and WHO guidance toolkit for COVID-19 vaccination demand,[42, 43] and a European Centre for Diseases Control (ECDC) document exploring vaccine hesitancy.[44] Our main outcomes of interest were migrants' perception about COVD-19 vaccination accessibility and their demand for COVID-19 vaccination. We also explored drivers and barriers for demands. Accessibility was investigated using the question: "Do you believe that migrants in your [legal] situation will have access to the COVID-19 vaccination?" with "yes", "no", and "I don't know" as possible responses; we dichotomized ''yes'' and ''I don't know" versus 'no'' in order to determine the proportion of participants perceiving that the vaccination would not be inaccessible. We further investigated the type of barrier in those responding "no". Demand was investigated using the question: "If the vaccine was offered to you, would you like to get immunized against COVID-19?". Responses to the latter question included "yes no doubt", "probably yes", "probably no", "no", "I don't know yet". In the analysis, we dichotomized ''yes no doubt" versus all other response to determine the proportion of vaccine-hesitant respondents, based on the definition of vaccine hesitance as the reluctance or refusal to vaccinate despite the availability of vaccines along a continuum with a broad spectrum of attitudes and intentions from active demand to passive acceptance, vaccine hesitancy, and refusal of all vaccines[44]. We explored enabling and barriers factors for vaccine accessibility and demand such as demographic characteristics, self-reported clinical risk factors for severe SARS-CoV-2 infection, previous infection with SARS-CoV-2 (self and/or household), self-perceived health risks with COVID-19, views about vaccination in general and COVID-19 vaccination in terms of safety and efficacy (both dichotomized as positive versus negative), desirable place of vaccination, and finally the main sources of information about COVID-19 vaccine (traditional media, social media, and community networks).

Study size

In absence of pre-existing hypothesis regarding the distribution of responses to the two main outcomes, considering the difference in the number of monthly visits in each site and the uncertainties about migrants' willingness to engage into the study in the different sites, we pragmatically set a minimal sample size of 100 participants per study site to be reached within the pre-defined study period.

Statistical analysis

Categorical data are presented as proportions with percentages and non-normally distributed continuous variable as median with interquartile range (IQR). We compared the distribution of variables in the four study sites using the Kruskal-Wallis test for non-normally distributed variables and the chi-square test or the Fisher's exact test, as appropriate. The significance level was set at 0.05.

We performed both univariate and multivariate logistic regression analysis to identify factors associated with the two main outcomes, and results were reported as odds ratios (OR) along with their 95% confidence intervals (CI). Missing data, which ranged from 0.2% to 3.6% of the total study size, were

imputed by assuming that data were missing at random with hundred imputations. All analysis were performed using SAS 9.4 (Cary, NC, USA).

Ethical review

The John Hopkins University (IRB00252774), Geneva Canton (CCER 2021-0246), and the University of Milan-Bicocca (138AQ-38183) ethical boards provided clearance for this survey. In France, the INSERM review board (IRB00003888) considered this study to be exempted of ethical clearance given the nature of the survey. The study was registered with the Office of the data protection (DPO) of Sorbonne Paris Nord University. All participants gave oral informed consent to participate.

Role of the funding source

The funders had no role in study design, or in data collection, analysis or interpretation.

Results

A total of 812 individuals completed the survey, 441 (54·3%) in Geneva, 142 (17·5%) in Baltimore, 126 (15·5%) in Milan, and 103 (12·7%) in Paris. The median age was 40·1 years (range 17-76) with a predominance of female respondents (60·9%), but gender distribution varied by city and, notably, 69·9% of participants in Paris were male (Table 1). They mainly originated from the Americas (55·9%), Africa (12·7%) and the Western Pacific regions (11·2%). Participants born in the Americas accounted for all the respondents in Baltimore, over half in Geneva and Milan, but only 1·9% in Paris, which had the largest representation of African migrants.

Table 1: Sociodemographic characteristics of the participants (n=812).

	Total N = 812, n (%) or median (IQR)	Geneva N = 441, n (%) or median (IQR)	Baltimore N = 142, n (%) or median (IQR)	Milan N = 12, n (%) or median (IQR)6	Paris N = 103, n (%) or median (IQR)	p-value
Female gender	492 (60·9)	279 (63·4)	98 (70·0)	84 (67·2)	31 (30·1)	< 0·001
Missing	4	1	2	1	0	
Age	39 (16)	39 (17)	40 (13)	41 (20)	35 (16)	0·001
Missing	2	1	0		1	
Region of origin						0·001
Africa	103 (12·7)	52 (11·8)	0 (0)	8 (6·4)	43 (41·8)	
Americas	454 (55·9)	227 (51·5)	142 (100)	83 (65·9)	2 (1·9)	
Eastern Mediterranean	64 (7·9)	28 (6·4)	0 (0)	7 (5·6)	29 (28·2)	
Europe	62 (7·6)	39 (8·8)	0 (0)	21 (16·7)	2 (1·9)	
Asia	38 (4·7)	7 (1·6)	0 (0)	6 (4·8)	25 (24·3)	
Western Pacific	91 (11·2)	88 (20·0)	0 (0)	1 (0·8)	2 (1·9)	
Missing	0	0	0	0	0	

The vast majority (86·4%) of participants perceived that the COVID-19 vaccination would be accessible to undocumented migrants, but a lower proportion (41·2%) reported they would get vaccinated against COVID-19 (Table 2).

Table 2: Undocumented migrants' perceived accessibility to and demand for COVID-19 vaccine with related enabling and barrier factors

	Total N = 812, n (%)	Geneva N = 441, n (%)	Baltimore N = 142, n (%)	Milan N = 126, n (%)	Paris N = 103, n (%)	p-value
Access to COVID-19 vaccination	697 (86·4)	377 (86·1)	116 (82·3)	110 (88·0)	94 (91·3)	0·219
Missing	5	3	1	1	0	
Demand for COVID-19 vaccination	327 (41·2)	168 (39·0)	79 (59·0)	65 (52·0)	15 (14·6)	< 0·001
	19	10	8	1	0	
COVID-19 exposure						
COVID-19 infection (self)	114 (14·1)	62 (14·1)	32 (22·5)	11 (8·7)	9 (8·8)	0·003
Missing	3	2	0	0	1	
COVID-19 infection (household)	129 (16·1)	74 (17·0)	35 (25·2)	17 (13·5)	3 (2·9)	< 0·001
Missing	9	6	3	0	0	
Clinical risk factors for severe COVID-19 infection						
Cardiovascular disease	109 (13·7)	46 (10·8)	14 (10·1)	34 (27·0)	15 (14·6)	< 0·001
Diabetes	85 (10·7)	21 (4·9)	27 (19·4)	13 (10·3)	24 (23·3)	< 0·001
Weight excess	79 (9·9)	29 (6·8)	22 (15·8)	16 (12·7)	12 (11·7)	0·010
Chronic lung disease	40 (5·0)	24 (5·6)	1 (0·7)	11 (8·7)	4 (3·9)	0·022
Chronic kidney disease	29 (3·7)	15 (3·5)	8 (5·8)	5 (4·0)	1 (1·0)	0·272
≥ 1 co-morbidity	234 (29·5)	96 (22·5)	52 (37·4)	57 (45·2)	29 (28·2)	< 0·001
Missing	18	15	3	0	0	
Views on COVID-19 risks and vaccination						

High self-perceived risk of severe COVID-19 infection	208 (26·2)	95 (22·0)	35 (25·7)	42 (33·9)	36 (35·0)	0·008
Missing	18	10	6	2	0	
Positive views on vaccination in general	605 (77·3)	300 (70·6)	126 (94·0)	98 (79·0)	81 (81·0)	< 0·001
Missing	29	16	8	2	3	
Positive views on COVID-19 vaccination	445 (56·5)	218 (51·1)	104 (77·6)	79 (63·7)	44 (42·7)	< 0·001
Missing	24	14	8	2	0	
Sources of information about COVID-19 vaccines						
Traditional media (TV, radio, web)	626 (79·3)	329 (76·9)	109 (82·0)	104 (83·2)	84 (81·6)	0·309
Social media	361 (45·8)	189 (44·2)	36 (27·1)	56 (44·8)	80 (77·7)	< 0·001
Community networks	214 (27·1)	99 (23·1)	6 (4·5)	34 (27·2)	75 (72·8)	< 0·001
Other	33 (4·2)	25 (5·8)	0 (0)	7 (5·6)	1 (1·0)	0·007
Missing	23	13	9	1	0	

Although perceptions about accessibility did not vary by city, demand ranged widely and was lowest (14.6%) among participants living in Paris. Respondents who did not believe that COVID-19 vaccination would be available to undocumented migrants reported lack of health insurance or card as the main barrier to access. Overall, most participants who intended to get vaccinated preferred to do so at a hospital (73·5%) (Tables 3 and 4).

Table 3: Perceived barriers to accessing to COVID-19 vaccination in participants mentioning vaccination being not accessible.

	Total N = 110, n (%)	Geneva N = 61, n (%)	Baltimore N = 25, n (%)	Milan N = 15, n (%)	Paris N = 9, n (%)
Lack of insurance/health card (National Health System)	57 (51·8)	32 (52·5)	14 (56·0)	9 (60·0)	2 (22·2)
High cost	25 (22·7)	17 (27·9)	2 (8·0)	3 (20·0)	3 (33·3)
Lack of eligibility to enroll in vaccination program	18 (16·4)	8 (13·1)	1 (4·0)	5 (33·3)	4 (44·4)
Not knowing where to go	27 (24·5)	13 (21·3)	9 (36·0)	3 (20·0)	2 (22·2)
Other reasons	13 (11·8)	6 (9·8)	0 (0)	5 (33·3)	2 (22.2)
Missing	0	0	0	0	0

Table 4: Preferred place for COVID-19 vaccination.

	Total N = 327, n (%)	Geneva N = 168, n (%)	Baltimore N = 79, n (%)	Milan N = 65, n (%)	Paris N = 15, n (%)
Hospital	236 (73·5)	144 (87·8)	40 (50·6)	39 (60·9)	13 (92·9)
Public health/community clinic	65 (20·2)	31 (18·9)	17 (21·5)	16 (25·0)	1 (7·1)
Private physician	20 (6·2)	4 (2·4)	3 (3·8)	11 (17·2)	2 (14·3)
Pharmacy	37 (11·5)	17 (10·4)	6 (7·6)	9 (14·1)	5 (35·7)
Charity	65 (20·2)	22 (13·4)	16 (20·3)	19 (29·7)	8 (57·1)
Other	10 (3·19)	4 (2·4)	2 (2·5)	4 (6·3)	0 (0)
Missing	6	4	0	1	1

Approximately one third (29·5%) of participants reported at least one chronic co-morbidity that could predispose to severe COVID-19 infection, 14·1% reported prior COVID-19 infection, and 26·2% worried about developing severe COVID-19 (Table 2). In all cities, perceptions about vaccination in general were more favorable than about COVID-19 vaccination overall, more than three quarters (77·3%) of respondents had positive views on vaccination in general, compared to (56·5%) about COVID-19 vaccination. Traditional media was the most common source of information about COVID-19 vaccination, followed by social media. Community networks were a common source of information among participants in Paris (72·8%), but less so among participants in other cities.

In univariate and multivariate analysis, female gender was the only factor positively associated with self-perceived accessibility to COVID-19 vaccination while participants originating from the Americas or recruited in Baltimore tended to be more confident about accessibility (Table 5).

Table 5: Factors associated with perceived accessibility of COVID-19 vaccination in regression analysis

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p-value	aOR (95% CI)	p- value
Study site Geneva	Reference		Reference	
Baltimore	0·75 (0·45-1·25)	0·276	0·56 (0·30-1·03)	0·063
Milan	1·20 (0·65-2·19)	0·562	1·07 (0·56-2·06)	0·838
Paris	1·70 (0·81-3·54)	0·160	2·24 (0·86-5·83)	0·100
Gender female	1·57 (1·04-2·35)	0·030	1·62 (1·03-2·56)	0·038
Age (per additional year)	1·01 (0·99-1·03)	0·272	1·01 (0·99-1·03)	0·511
Region of origin Europe	Reference		Reference	
Africa	1·82 (0·78-4·23)	0·165	1·64 (0·66-4·05)	0·286
Americas	1·77 (0·90-3·46)	0·095	1·97 (0·93-4·16)	0·075
Eastern Mediterranean	2·56 (0·91-7·25)	0·225	2·13 (0·71-6·36)	0·175
South-East Asia	1·12 (0·40-3·13)	0·827	0·84 (0·25-2·79)	0·773
Western Pacific	1·72 (0·72-4·06)	0·220	1·39 (0·55-3·48)	0·484

≥1 clinical risk factors	1·24 (0·79-1·97)	0·352	1·18 (0·70-2·00)	0·533
High self-perceived risk of severe COVID-19	0·89 (0·55-1·42)	0·615	0·90 (0·54-1·49)	0·681
COVID-19 infection (self)	1·06 (0·60-1·88)	0·841	1·01 (0·52-1·99)	0·968
COVID-19 infection (household)	0·88 (0·51-1·50)	0·637	0·90 (0·47-1·70)	0·737
Positive views on vaccination in general	1·39 (0·88-2·20)	0·158	1·33 (0·74-2·39)	0·336
Positive views on COVID-19 vaccination	1·14 (0·76-1·72)	0·518	1·18 (0·71-1·98)	0·519
Information through traditional media (TV, radio, web)	1·19 (0·73-1·93)	0·494	1·20 (0·69-2·11)	0·515
Information through social media	1·29 (0·85-1·94)	0·234	1·21 (0·75-1·96)	0·427
Information through community network	1·22 (0·76-1·97)	0·409	1·00 (0·58-1·74)	0·998
Information through other source	2·39 (0·57-10·11)	0·236	3·13 (0·70-14·08)	0·137

Demand for vaccination, on the other hand, was associated with a variety of factors (Table 6). Before adjustment, living in the US and Italy, female gender, older age, comorbidity, perception of being at risk of severe COVID-19, positive views on vaccination including COVID-19 and mentioning traditional media as the main source of information were all associated with more chance to demand the vaccination. On the other hand, living in France and using social media and community networks as the preferred sources of information were negatively associated with demand. After adjustment, increasing age, the presence of co-morbidities, and positive views about vaccination in general and COVID-19 in particular were all significantly associated with increased demand for vaccination, while living in France and relying on community network to get informed were associated with lower demand. Of note, the preference for social media lost its significant negative association with demand after adjustment. Although not statistically significant, there was a trend toward more demand among African migrants.

Table 6: Factors associated with demand for COVID-19 vaccination in regression analysis

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p-value	aOR (95% CI)	p-value
Study site Geneva	Reference		Reference	
Baltimore	2·24 (1·51-3·33)	<0·001	0·97 (0·56-1·68)	0·920
Milan	1·70 (1·14-2·54)	0·009	1·18 (0·66-2·09)	0·578
Paris	0·26 (0·15-0·47)	<0·001	0·15 (0·06-0·38)	<0·001
Gender female	1.43 (1.07-1.92)	0.016	1.23 (0.80-1.88)	0.344
Age (per additional year)	1.04 (1.02-1.05)	<0.001	1.02 (1.00-1.04)	0.019
Region of origin Europe	Reference		Reference	
Africa	0.75 (0.38-1.46)	0.396	2.73 (0.93-8.02)	0.069

Americas	1.62 (0.94-2.80)	0.085	0.85 (0.36-1.96)	0.695
Eastern Mediterranean	0.93 (0.45-1.93)	0.852	1.93 (0.63-5.86)	0.247
South-East Asia	0·38 (0·15-1·01)	0·052	0·45 (0·12-1·65)	0·231
Western Pacific	0·90 (0·46-1·78)	0·769	0·69 (0·26-1·87)	0·467
≥ 1 co-morbidity	1·91 (1·40-2·61)	<0·001	1·77 (1·10-2·84)	0·018
High self-perceived risk of severe COVID-19	1·46 (1·06-2·01)	0·019	1·26 (0·81-1·96)	0·315
COVID-19 infection (self)	1·37 (0·92-2·05)	0·124	1·23 (0·66-2·27)	0·514
COVID-19 infection (household)	1·23 (0·84-1·79)	0·292	0·84 (0·48-1·49)	0·557
Positive views on vaccination (general)	32·5 (14·2-74·4)	<0·001	12·9 (5·17-32·22)	<0·001
Positive views on vaccination (COVID-19)	16·70 (11·2-24·8)	<0·001	9·70 (6·08-15·47)	< 0·001
Information through traditional media (TV, radio, web)	2·25 (1·53-3·29)	<0·001	1·28 (0·75-2·18)	0·360
Information through social media	0·47 (0·35-0·62)	<0·001	0·84 (0·55-1·28)	0·410
Information through community network	0·47 (0·33-0·65)	<0·001	0·61 (0·38-1·00)	0·049
Information through other source	0·30 (0·12-0·73)	0·008	0·44 (0·13-1·43)	0·170
Self-perceived accessibility to COVID-19 Vaccination	1·19 (0·78-1·81)	0·421	1·08 (0·61-1·92)	0·799

Discussion

This study shows that during the early phase of the COVID-19 immunization program in four cities in Europe and the US, most undocumented migrants believed the COVID-19 vaccine would be available to them, but fewer intended to get vaccinated. During this period, participants listed traditional media as the most common source of information, followed by social media and community networks. Although perceptions about vaccination in general were positive, they were much lower for COVID-19 vaccination. These findings provide insights about the perception and demand for COVID-19 vaccination among undocumented migrants during the initial phase of the vaccination program and can help strengthen it as currently ongoing as well as inform the early response for future initiatives. Traditional media appears to play an important role at the early stage and positive views about general immunization programs should be leveraged through community engagement and messaging in various languages to address issues of particular concern to undocumented migrants, such as safety of the COVID-19 vaccines, confidentiality, and implications on immigration status.

The high confidence in COVID-19 vaccination access among undocumented migrants is telling given their frequent exclusion from many public health benefits. This is reassuring given the legitimate concern that access to vaccination would be limited for this population. Early in the vaccination roll-out, qualitative

research among primarily female migrant farmworkers in the US and migrants with precarious immigration status in the UK showed that misinformation and lack of awareness about entitlements, including access to COVID-19 vaccines, could present substantial barriers to immunization programs.[45,46] In our study, women were more likely to endorse access than men. This could be related to increased familiarity with the vaccination programs and overall health system through the use of reproductive health services and as traditional caregivers for children.[47]

The gap between accessibility and demand is concerning. In our study, there was regional variability, with the lowest demand among participants from Paris. Information from community networks tended also to be associated with low demand for vaccination and was more common in Paris, highlighting the need for targeted approaches for different communities. In Paris, the level of literacy (though not measured) may have been lower, given that most respondents could not fill in the questionnaire themselves but had to be helped. This would impact on the potential source of information: information through community networks is more easily accessible in case of language barriers. Also, the second most common source of information was social media, in which content is uncontrolled, opening the debate on how to use social media to harness vaccine hesitancy. Higher demand for vaccination among older people and those with co-morbidities is consistent with global trends and may reflect the risk-benefit calculus for people at higher risk of hospitalization and death from COVID-19. Interestingly, high self-perceived risk of COVID-19 or prior COVID-19 infection were not associated with demand for vaccination, perhaps because this includes mild cases of the disease.

Intention to get vaccinated against COVID-19 has evolved over time. The successful implementation of large-scale immunizations programs has encouraged many previously hesitant individuals to get vaccinated, but misinformation and fake news continue to fuel mistrust and slow progress in terms of immunization coverage in many settings. In our study, only two in five individuals reported they would get vaccinated if the COVID-19 vaccine was offered to them. Although comparison with other groups is difficult due to heterogeneity of methods and timing, hesitancy appears to be higher in our sample compared to the general adult population in the countries studied. For example, in a survey conducted in Italy in December 2020, 82% of adults reported willingness to get vaccinated compared to 52% of our study participants from Milan.[48] Similarly, in a survey conducted in France in June 2020, 71.8% of participants reported they would accept vaccination compared to only 14.6% of our Paris participants.[49] An international cross-sectional survey conducted between September 2020 and January 2021, however, showed lower intention to get vaccinated among participants from France (49.2%).[50] Of note, all these surveys were conducted online, with likely bias towards higher educational and socioeconomic status. Specific data on undocumented migrants is very limited, but in a survey conducted in the US in late April 2021, 68% of respondents classified as potentially undocumented reported that they had either been vaccinated or planned to get vaccinated.[51]

This study has limitations. Participant recruitment was nonrandom and occurred in health facilities serving undocumented migrants, thereby involving a non-representative sample population of neither the health facilities' clients nor undocumented migrants at large, and therefore limiting the generalizability of our findings. Furthermore, the questionnaire was translated in 8 languages and translators were not systematically available during questionnaire administration, hence it is possible that participants speaking a different language had a limited understanding about the questionnaire, thus introducing an information bias and limiting response accuracy. Confidence about access to the COVID-19 vaccine and desire to be vaccinated may differ for undocumented migrants who have not interacted with the health system in their country of residence. Nonetheless, approximately half of respondents in our sample identified lack of health insurance/health card as a major barrier to COVID-19 vaccination. Although

concerns about immigration have been shown to dampen healthcare utilization for COVID-19 services among undocumented migrants,[52] we did not specifically ask whether worries about immigration repercussions impacted demand. In our study, public hospitals or clinics were identified as preferred sites for vaccination among those intending to get vaccinated, but we did not collect information about trust in public institutions among vaccine hesitant participants.

In summary, our study showed a substantial gap between undocumented migrants' perceptions about access to COVID-19 vaccines and demand for vaccination. The World Health Organization, UNICEF, the UN High Commissioner for Refugees, the European Centre for Disease Prevention and Control (ECDC) and the Council of Europe have issued recommendations urging access to COVID-19 vaccination to all vulnerable populations, including low-income countries, undocumented migrants, and refugees.[33] Our results show that building trust and confidence in COVID-19 vaccination is as important as promoting access. Given the marginalization and criminalization of undocumented migrants, this may not be simple and requires tailored local solutions. Our data suggests that during the first phase of a new vaccination program as for COVID-19, traditional media is an important source of information and communities need to be engaged to leverage existing confidence in general vaccination programs to reduce hesitancy. Community engagement is also important to adequately inform and guide community networks, which can be influential but may undermine vaccination efforts unless equipped with official and verified information. Controlling the ongoing COVID-19 pandemic requires equitable vaccine distribution to everyone, with tailored measures to reach out and include undocumented migrants, and high uptake in all groups. Tailored efforts to specifically address concerns and mitigate fears among undocumented migrants are needed for the protection of all.

Declaration of interest

Authors declare no conflict of interest.

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Authors' statement

YJ: conceptualization, methodology, supervision and writing - review and editing
KP: conceptualization, methodology and writing - original draft
EG: conceptualization, methodology, and writing - review and editing
JC: conceptualization, methodology, and writing - review and editing
MF: data curation, formal analysis and writing - review and editing
AD: data curation and writing - review and editing
SC: investigation and writing - review and editing
GF: investigation and writing - review and editing
RT: investigation and writing - review and editing
SS: investigation and writing - review and editing

Data statement

The full dataset will be available on the University of Geneva repository (doi: to be defined)

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Supplementary material

Questionnaire on intent to be immunized against Covid-19 amongst undocumented migrants

In order to properly meet your health needs, we would like to hear your opinion on the COVID-19 vaccination. This information is anonymous and confidential.
Please tick the correct answer (s)

1. Gender
    a. ☐ Female
    b. ☐ male
2. Age
3. Country of birth
4. Have you suffered from a COVID-19 infection (one choice)
    a. ☐ No
    b. ☐ Yes probably but I haven't been tested
    c. ☐ Yes and I have been tested
5. If yes, when (month/year)?
6. Has somebody living at the same place as you (family or friend) suffered from a COVID-19 infection (one choice)
    a. ☐ No
    b. ☐ Yes probably but she/he hasn't been tested
    c. ☐ Yes and she/he has been tested
7. Do you have any of the following medical conditions that could put you at risk for severe COVID-19 infection (multiple choices)
    a. ☐ High blood pressure (hypertension) or a cardiac (heart) condition
    b. ☐ Diabetes

c. ☐ Excessive weight

d. ☐ Chronic disease of the lungs

e. ☐ Chronic disease of the kidneys

f. ☐ No

g. ☐ I don't know

8. What do you think is the risk to your health related to COVID-19 (multiple choices)

a. ☐ I think the risk is too low to worry

b. ☐ I follow the recommendations about protection, this is sufficient to be protected

c. ☐ I don't think I am at risk of a severe infection

d. ☐ I already got COVID-19 so there is no more risk

e. ☐ I prefer being infected to develop my own immunity

f. ☐ I am worried about developing a severe form of COVID-19

g. ☐ I don't know

9. Do you believe that migrants/persons in your situation will have access to the COVID-19 vaccines here in Italy/Switzerland/France/The USA (one choice)

a. ☐ Yes

b. ☐ No

c. ☐ I don't know

10. If no, for what reasons (multiple choices)

a. ☐ Lack of health insurance/health card

b. ☐ High cost

c. ☐ Lack of right to enroll into immunization programs

d. ☐ Don't know where to go

e. ☐ Other reason

11. If the vaccine is offered to you, would you like to get immunized against COVID-19 (one choice)

a. ☐ Yes, no doubt

b. ☐ Probably yes

c. ☐ Probably no

d. ☐ No

e. ☐ I haven't decided yet

12. If yes, where could you receive the vaccine (multiple choices)

a. ☐ Hospital

b. ☐ Private doctor

c. ☐ Pharmacy

d. ☐ Community organization, charity

e. ☐ Public health clinic

f. ☐ Other

13. What is your point of view about vaccines in general (multiple choices)

a. ☐ I trust vaccines

b. ☐ I believe it will protect me

c. ☐ I am against vaccines in general

d. ☐ I prefer alternative remedies

e. ☐ I believe I can resist to infections without vaccines

f. ☐ If I have to suffer an infection, vaccine won't help for that

14. What is your point of view about the COVID-19 vaccines (multiple choices)

a. ☐ I trust the COVID-19 vaccine

b. ☐ I believe it will protect me

c. ☐ I don't trust in vaccines using genetic material

d. ☐ I am afraid of negative effects

e. ☐ I think it won't protect me long enough

f. ☐ I don't want to receive two doses

g. ☐ I already had COVID-19 so I don't think I need it

15. How do you access to information about COVID-19 vaccines (multiple choices)

a. ☐ TV, radio, newspapers in Italy/Switzerland/France/The USA

b. ☐ TV, radio, newspapers from my country of origin

c. ☐ Websites of the hospital/health authority in Italy/Switzerland/France/The USA

d. ☐ Website of the government in Italy/Switzerland/France/The USA

e. ☐ Social media (Facebook, YouTube, Instagram, WhatsApp, etc.)

f. ☐ Friends and relatives

g. ☐ Other

Thank you very much for your participation

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

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In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	#4	Present key elements of study design early in the paper	4
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4

Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	5
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	6
Bias	#9	Describe any efforts to address potential sources of bias	5
Study size	#10	Explain how the study size was arrived at	6
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	6
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	6
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	7
Statistical methods	#12c	Explain how missing data were addressed	7
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	n/a
Statistical methods	#12e	Describe any sensitivity analyses	7
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	7
Participants	#13b	Give reasons for non-participation at each stage	n/a
Participants	#13c	Consider use of a flow diagram	n/a
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	7
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	8

Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	8
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	n/a
Main results	#16b	Report category boundaries when continuous variables were categorized	n/a
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	9-12
Discussion			
Key results	#18	Summarise key results with reference to study objectives	12
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	13
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	13
Generalisability	#21	Discuss the generalisability (external validity) of the study results	13
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

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COVID-19 vaccine hesitancy among undocumented migrants during the early phase of the vaccination campaign: a multi-centric cross-sectional study

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Abstract

Study objectives:
The marginalization of undocumented migrants raises concerns about equitable access to COVID-19 vaccination. This study aims to describe migrants' hesitancy about the COVID-19 vaccination during the early phase of the vaccination campaign.

Setting:
This multi-centric cross-sectional survey was conducted in health facilities providing care to undocumented migrants in the United States, Switzerland, Italy, and France in February-May 2021.

Participants:
Eligibility criteria included age >16, being of foreign origin and living without valid residency permit in the country of recruitment. A convenience sample of minimum 100 patients per study site was targeted.

Primary and secondary outcome measures:
Data was collected using an anonymous structured questionnaire. The main outcomes were perceived access to the local COVID-19 vaccination program and demand for vaccination.

Results:
Altogether, 812 undocumented migrants participated (54.3% Geneva, 17.5% Baltimore, 15.5% Milano and 12.7% Paris). Most (60.9%) were women. The median age was 40 years (range 17-76). Participants originated from the Americas (55.9%), Africa (12.7%), Western Pacific (11.2%) Eastern Mediterranean (7.9%), Europe (7.6%) and South-East Asia (4.7%). Overall, 14.1% and 26.2% of participants, respectively, reported prior COVID-19 infection and fear of developing severe COVID-19 infection. Risk factors for severe infection were frequently reported (29.5%). Self-perceived accessibility of COVID-19 vaccination was high (86.4%), yet demand was low (41.1%) correlating with age, co-morbidity, and views on vaccination which were better for vaccination in general (77.3%) than vaccination against COVID-19 (56.5%) Participants mainly searched for information about vaccination in the traditional and social media.

Conclusions:
We found a mismatch between perceived accessibility and demand for the COVID-19 vaccination. Public health interventions using different communication modes should build on trust about vaccination in general to tackle undocumented migrants' hesitancy for COVID-19 vaccination with a specific attention to men, younger migrants and those at low clinical risk for severe infection.

Trial registration: non

Strengths and limitations

- The study included undocumented migrants, a hard to reach population, in four countries
- Efforts were made to overcome language, trust and literacy barriers to participation
- The number of participants differed in every study sites

Introduction

It is estimated that between 3.9 and 4.8 million undocumented migrants live in Europe and 10.5 million in the United States (US).[1-3] Economic opportunities, integration policies, and the rights and benefits

afforded to undocumented migrants vary by host country. However, challenges including language barriers, fear of deportation, poverty, housing precariousness, and limited access to healthcare and workplace protections, are common experiences for most undocumented migrants.

Although undocumented migrants represent less than 1% of Europe's and 3.2% of the US total population, emerging evidence points to the devastating impact of COVID-19 in this group. In high-income countries, migrants have high risk of COVID-19 infection, morbidity, and mortality.[4] Although COVID-19 outcomes by specific immigration status are rarely available, surrogate markers (e.g. language, country of origin, housing status, health insurance eligibility, and demographics) suggest that undocumented migrants are at particularly high risk.[4-13] Community and health facility-based studies in Europe and the US showed exceptionally high SARS-CoV-2 positivity rates among foreign-born or limited English proficiency patients.[7,8,14,15] In the US, COVID-19 case rates were highest in counties with large immigrant communities, and the correlation was stronger in areas with more Central Americans, a group with high poverty levels and irregular migrant status .[1,12,16] In addition, there is evidence of poor outcomes due to delayed presentation to care among undocumented migrants.[4,6,10,17,18] Mortality data by migrant status is limited, but what is available shows that compared to native-born citizens, migrants to Europe and the US, particularly those from low and middle-income countries, have higher excess all-cause and COVID-19 mortality. [19-23]

Undocumented migrants play an essential role in the global economy but rely heavily on informal and low-wage labor with limited occupational protections. Mitigation strategies to reduce the social, economic and health impact of the COVID-19 pandemic frequently exclude undocumented migrants. Without a social safety net, many continued to work at the peak of the pandemic in high-risk essential jobs, such as logistics, manufacturing, domestic and care activities, construction, and the food processing industry.[11,24,25] Several European countries provided food assistance to migrants during lockdown, and a few further extended benefits. For example, Ireland implemented a system to pay unemployment benefits to undocumented migrants who lost their jobs, and Portugal granted temporary citizenship rights to migrants.[26] The suspension of exclusionary immigrant policies, however, was not uniform and there were many unmet needs and many vulnerable undocumented migrants fell into extreme poverty.[26] A survey conducted in Switzerland in April 2020 showed that almost one in six migrants had experienced hunger during the first lockdown.[27]

Furthermore, long-standing anti-immigrant policies and mistrust of governmental institutions have not been eased during the pandemic, and pre-existing legal, socio-economic, and linguistic barriers to social and health services have exacerbated the impact of COVID-19 among undocumented migrants. [28,29] Although countries deployed health services for COVID-19 without eligibility restrictions based on migration status, no specific measure has been implemented to facilitate access for undocumented migrants who already tended to underutilize social and health services even before the pandemic.[30,31] As a result, pre-existing barriers to accessing health and social services are exacerbated by the pandemic and likely lead to delaying life-saving care for many.[6,10,11,27]

The rapid development of effective COVID-19 vaccines was an unprecedented scientific achievement, but equitable vaccine distribution is a major challenge worldwide. Undocumented migrants and other socially disadvantaged populations have faced significant hurdles to get vaccinated, including digital, transportation, and health system navigation barriers. The European Centre for Disease Prevention and Control (ECDC) and the Council of Europe have called for tailored vaccination programs for undocumented migrants that are free from immigration control enforcement activities,[32] but only a few national immunization plans explicitly include provisions for undocumented migrants, or address potential

barriers, such as langauge proficiency or identification requirements.[33,34] In addition, the willingness and hesitancy of individuals, including undocumented migrants, to get immunized depends on a variety of factors, such as self-perceived risks and severity of illness; confidence in the safety and effectiveness of the vaccine; trust in medical, govermental, or pharmaceutical institutions; behavioral and social processes (e.g. awareness, information, education, social norms, networks, and media). The objective of this multi-centric study conducted in the early phase of COVID-19 immunization programs was to explore undocumented migrants' hesitancy about COVID-19 vaccine.

Methods

Design

This multi-centric cross-sectional survey was conducted from mid-February to late May 2021 in four facilities providing medical care to undocumented migrants in Switzerland, the United States, Italy, and France during the early phase of the vaccination campaign (February to May 2021).

Setting

The four study sites are part of an informal network of health institutions providing care to undocumented migrants which started to share experiences and good practices during the early phase of the COVID-19 pandemic.

Geneva, Switzerland

Geneva (population 500,000) hosts an estimated 10,000 to 15,000 undocumented migrants, predominantly women from Latin America, the Philippines and South-Eastern Europe who are active in the domestic and care industry.[35] While potentially eligible to purchasing the mandatory health insurance to access to medical care, less than 10% are actually insured because of financial and administrative barriers. The Geneva University Hospital acts as the main port of entry into the healthcare system for undocumented migrants and other underserved groups of population, providing the full range of preventive, curative and rehabilitation health services.[36] While the Swiss Federal Government has decided upon the universal access to COVID-19 vaccination to all residents irrespective of their legal status in early 2021, the policy implementation has been delayed at Canton level and Geneva was the first Canton to officially integrate undocumented migrants into the vaccination program in May 2021.[37] At the beginning of the study, the COVID-19 incidence and mortality in Canton Geneva were at their lowest since October 2020. There was then a mild resurgence of new cases not associated with increased mortality that peaked in April before coming back to its baseline in May. The vaccination campaign started on December 28, 2020. Two vaccines were available, BNT162b2 mRNA (Pfizer/BioNTech) and mRNA-1273 (Moderna). In the first two months, vaccination was limited to high risk groups and it became available to all adults in early March 2021. By the end of the study, 37% of the population had received at least one dose. No additional public restrictions were imposed during the study period.

Milan, Italy

According to available estimates, there are currently 517,000 undocumented migrants in Italy.[38] Disaggregated estimates at city level including for Milan are not readily available. However, Milan is the economic center and the most populous region in Italy, hence likely to host a large population of

undocumented migrants. In principle, the National Health Service system is based on a universalistic model providing healthcare free of charge at the point-of-use against payment of standard flat fees with waivers based on socio-economic criteria and is decentralized at regional level for both policy and service delivery aspects. Access to the NHS requires a valid health card, which is issued based on residency status. As a result, undocumented migrants do not have access to the NHS. To address this fundamental legal and administrative barrier, the NHS provides a temporary access code, which allows access to emergency care and essential services including maternity and vaccination services. In practice, undocumented migrants face barriers even to obtain a temporary access code and rely on charities for accessing healthcare. Among them, ''Opera San Francesco per i Poveri'' is a faith-based charity operating a large size health clinic in Milan providing free-of-charge outpatient healthcare including consultations, diagnostics, and therapy for socially disadvantaged population groups including undocumented migrants. For COVID-19 vaccination, the NHS procures and distributes vaccines and consumables, while the regional health system administers them through a client-initiated online booking system requiring a valid health card. As of 25th June 2021, the Lombardy Region, with Milan as the chief lieu, granted eligibility for online booking to undocumented migrants with a temporary access code. Charities have mobilized to provide individual support to facilitate administrative, linguistic and practicality challenges. At study inception, COVID-19 incidence and mortality were persistently elevated in Italy. The Lombardy Region, with Milan as its chief-lieu, continued to account for the highest toll in-country. Restrictions including lockdown continued to be implemented in a modular way according to local epidemiology. The national immunization campaign kicked off officially just before the end of 2020, targeting the health workforce and the elderly in hospices; however, it struggled to pick up pace until summer 2021 and only 1.2% of total target population was fully immunized at study inception. Initially, the campaign used BNT162b2 mRNA, then mRNA-1273, ChAdOx1 nCoV-19 AZD1222 (Astra-Zeneca), and finally added JNJ-78436735 (Johnson & Johnson) vaccines, the latter having been prioritized for hard-to-reach population groups including undocumented migrants.Baltimore, USA

Baltimore City is an emergent destination for migrants from Latin America.[39] An estimated 20,000 foreign-born Latin Americans live in the city and approximately 13,500 (67%) are not citizens. Migrants from Mexico and Central America have higher non-citizen status (> 80%), low educational attainment (50% with less than high school education), and high rates (70%) of limited English proficiency.[40] In the US, the COVID-19 vaccine is freely available to all, regardless of immigration or insurance status, and the Department of Homeland Security has explicitly stated that immigration enforcement activities will not be conducted at vaccination site.[41] In the early stages of the COVID-19 immunization program, the state of Maryland implemented a phased distribution plan and the vaccine was not available to the general population until April 27, after data collection for this study was completed. The Access Program, Johns Hopkins Medicine in Baltimore, Maryland (TAP) acts as the main port of entry into the Johns Hopkins Health System. Patients are enrolled in TAP if they are low income (<200% federal poverty line) and are ineligible to enroll in Medicaid or subsidized health insurance because of their irregular immigration status. In Baltimore City, cases of COVID-19 in February of 2021 were the lowest since October 2020, but by March 2021, a fourth wave of COVID-19 emerged which peaked on April 10, 2021. COVID-19 vaccine administration began on December 14, 2020 in a phased approach which sequentially prioritized first responders, the elderly and those with underlying health conditions. The vaccine became available to the general population on April 27, 2021. Three COVID-19 vaccines authorized in the US for Emergency Use or FDA-approved were available for vaccination programs: BNT162b2 mRNA, mRNA-1273 and JNJ-78436735.

Paris, France

Avicenne University hospital is located in the Department of Seine Saint Denis in the North-East of Paris. The Department is historically a place where migrants use to be provided social lodging after the Second World War (mainly Sub-Saharan Africa and North-African communities). It is estimated that more than 30% of the population is constituted of immigrants, with recently an additional wave of migrants from South Asia. Moreover, the majority of undocumented migrants in metropolitan France (around 400.000) tend to be concentrated in this Department. Undocumented migrants in France have access to health via State Medical Aid, an insurance coverage for individuals with no right to National Health Insurance. Those without any coverage may access health care via specific units created for uninsured persons (PASS, Permanence d'accès aux soins), located in hospitals principally. Avicenne University Hospital receives uninsured persons via this unit on a daily basis. In France, all eligible persons are entitled to Covid19 vaccination, as per government declaration. In Paris region, incidence of COVID-19 mid-February 2021 was already high at 237/100,000 inhabitants, and quickly increased further. A third lockdown was ordered on March 18, when incidence was at 426/100,000. The incidence peaked at the end of April, at 682/100,000, and slowly decreased. The survey hence took place about one month before the lockdown when virus circulation was already quite high, with a regional curfew in place since mid-January. The rate of study site enrollment was further affected by the lockdown and the increased police controls. COVID-19 vaccine national campaign began on December 27, 2020 in a phased approach which first prioritized the elderly, and those with underlying health conditions. The vaccine became available to the general population on January 18, 2021, while its uptake was very slow during the first weeks. The four COVID-19 vaccines authorized in France for were BNT162b2 mRNA, mRNA-1273, ChAdOx1 nCoV-19 AZD1222 and JNJ-78436735.Participants

Eligibility criteria were age equal or above 16 and living as a foreigner without valid residency permit (undocumented) in the country of recruitment. Participants were recruited upon spontaneous presentation (walk-in) to one of the participating health facilities.

We used several strategies to reduce the risk of recruitment and measurement bias by addressing the main barriers limiting undocumented migrants' participations in health programs such as fear of personal data misuse and socio-cultural factors. All consecutive patients consulting at the four health facilities were informed about the study orally and with written material in different languages. We explained that the questionnaire was anonymous, and that no identifying information was collected considering the frequent fear of undocumented migrants to disclose personal information. The questionnaire was translated in French, Spanish, Italian, Portuguese, Arabic, English, Tagalog, Albanian, Ukrainian, and Russian to match with the main languages spoken by migrants visiting the participating health facilities. Participants were proposed the support of research assistants competent in various languages to fill the questionnaire to overcome potential difficulties in reading and understanding the questions.

Data source and variables

We designed a 15-item questionnaire (Supplementary material) based on UNICEF and WHO guidance toolkit for COVID-19 vaccination demand,[42, 43] and a European Centre for Diseases Control (ECDC) document exploring vaccine hesitancy.[44] Our main outcome of interest was COVID-19 vaccine hesitancy explored through two main perspectives, perception about vaccination accessibility and the drivers and barriers for demands. Accessibility was investigated using the question: "Do you believe that migrants in your [legal] situation will have access to the COVID-19 vaccination?" with "yes", "no", and "I don't know" as possible responses; we dichotomized ''yes'' and ''I don't know" versus 'no'' in order to determine the proportion of participants perceiving that the vaccination would not be inaccessible. We further investigated the type of barrier in those responding "no". Demand was investigated using the question:

"If the vaccine was offered to you, would you like to get immunized against COVID-19?". Responses to the latter question included "yes no doubt", "probably yes", "probably no", "no", "I don't know yet". In the analysis, we dichotomized ''yes no doubt" versus all other response to determine the proportion of vaccine-hesitant respondents, based on the definition of vaccine hesitance as the reluctance or refusal to vaccinate despite the availability of vaccines along a continuum with a broad spectrum of attitudes and intentions from active demand to passive acceptance, vaccine hesitancy, and refusal of all vaccines[44]. We explored enabling and barriers factors for vaccine accessibility and demand such as demographic characteristics, self-reported clinical risk factors for severe SARS-CoV-2 infection, previous infection with SARS-CoV-2 (self and/or household), self-perceived health risks with COVID-19, views about vaccination in general and COVID-19 vaccination in terms of safety and efficacy (both dichotomized as positive versus negative), desirable place of vaccination, and finally the main sources of information about COVID-19 vaccine (traditional media, social media, and community networks). The questionnaire was pretested in 10 participants before being implemented in all study sites.

Study size

In absence of pre-existing hypothesis regarding the distribution of responses to the two main outcomes, considering the difference in the number of monthly visits in each site and the uncertainties about migrants' willingness to engage into the study in the different sites, we pragmatically set a minimal sample size of 100 participants per study site to be reached within the pre-defined study period.

Patient and Public Involvement

This study was informed by patients expressing interest and concerns to healthcare workers about COVID-19 vaccine accessibility and safety in the four study sites.

Statistical analysis

Categorical data are presented as proportions with percentages and non-normally distributed continuous variable as median with interquartile range (IQR). We compared the distribution of variables in the four study sites using the Kruskal-Wallis test for non-normally distributed variables and the chi-square test or the Fisher's exact test, as appropriate. The significance level was set at 0.05.

We performed both univariate and multivariate logistic regression analysis to identify factors associated with the two main outcomes. Odds ratios were estimated through multivariate logistic regression models, which were mutually adjusted with all covariates in the models. Missing values, which ranged from 0.2% to 3.6% of the total study size, were imputed by using a multiple (n=100) imputation approach. Briefly, multiple imputation is a bayesian method that allows to take into account incomplete cases (i.e. observations with any missing data) with a two-step approach. First, this method creates multiple imputed datasets, in which missing values are replaced by imputed values. These are sampled from their predictive distribution based on the observed data. The imputation procedure fully accounts for the uncertainty in predicting the missing values by conferring appropriate variability into the multiple imputed values. Second, standard statistical methods are used to fit the model of interest to each of the imputed datasets. Estimates associated to each of the imputed datasets differ because of the variation introduced in the imputation of the missing values (stage 1), and they are, then, average together to give overall estimated associations. Valid inferences are obtained because they are based on the average of the distribution of the missing data given the observed data, and results were reported as odds ratios (OR) along with their 95% confidence intervals (CI). All analysis were performed using SAS 9.4 (Cary, NC, USA).

Ethical review

The John Hopkins University (IRB00252774), Geneva Canton (CCER 2021-0246), and the University of Milan-Bicocca (138AQ-38183) ethical boards provided clearance for this survey. In France, the INSERM review board (IRB00003888) considered this study to be exempted of ethical clearance given the nature of the survey. The study was registered with the Office of the data protection (DPO) of Sorbonne Paris Nord University. All participants gave oral informed consent to participate.

Role of the funding source

The funders had no role in study design, or in data collection, analysis or interpretation.

Results

Participants' characteristics

A total of 812 individuals completed the survey, 441 (54.3%) in Geneva, 142 (17.5%) in Baltimore, 126 (15.5%) in Milan, and 103 (12.7%) in Paris. The median age was 40.1 years (range 17-76) with a predominance of female respondents (60.9%), but gender distribution varied by city and, notably, 69.9% of participants in Paris were male (Table 1). They mainly originated from the Americas (55.9%), Africa (12.7%) and the Western Pacific regions (11.2%). Participants born in the Americas accounted for all the respondents in Baltimore, over half in Geneva and Milan, but only 1.9% in Paris, which had the largest representation of African migrants.

Table 1: Sociodemographic characteristics of the participants (n=812).

	Total N = 812, n (%) or median (IQR)	Geneva N = 441, n (%) or median (IQR)	Baltimore N = 142, n (%) or median (IQR)	Milan N = 126, n (%) or median (IQR)	Paris N = 103, n (%) or median (IQR)	p-value
Female gender	492 (60.9)	279 (63.4)	98 (70.0)	84 (67.2)	31 (30.1)	< 0.001
Missing values	4	1	2	1	0	
Age	39 (16)	39 (17)	40 (13)	41 (20)	35 (16)	0.001
Missing values	2	1	0		1	
Region of origin						0.001
Africa	103 (12.7)	52 (11.8)	0 (0)	8 (6.4)	43 (41.8)	
Americas	454 (55.9)	227 (51.5)	142 (100)	83 (65.9)	2 (1.9)	
Eastern Mediterranean	64 (7.9)	28 (6.4)	0 (0)	7 (5.6)	29 (28.2)	
Europe	62 (7.6)	39 (8.8)	0 (0)	21 (16.7)	2 (1.9)	
Asia	38 (4.7)	7 (1.6)	0 (0)	6 (4.8)	25 (24.3)	
Western Pacific	91 (11.2)	88 (20.0)	0 (0)	1 (0.8)	2 (1.9)	
Missing values	0	0	0	0	0	

Accessibility and demand for vaccination and risk factors for severe infection

The vast majority (86.4%) of participants perceived that the COVID-19 vaccination would be accessible to undocumented migrants, but a lower proportion (41.2%) reported they would get vaccinated against COVID-19 (Table 2). Approximately one third (29.5%) of participants reported at least one chronic co-morbidity that could predispose to severe COVID-19 infection, 14.1% reported prior COVID-19 infection, and 26.2% worried about developing severe COVID-19 (Table 2). In all cities, perceptions about vaccination in general were more favorable than about COVID-19 vaccination overall, more than three quarters (77.3%) of respondents had positive views on vaccination in general, compared to (56.5%) about COVID-19 vaccination. Traditional media was the most common source of information about COVID-19 vaccination, followed by social media. Community networks were a common source of information among participants in Paris (72.8%), but less so among participants in other cities.

Table 2: Undocumented migrants' perceived accessibility to and demand for COVID-19 vaccine with related enabling and barrier factors

	Total N = 812, n (%)	Geneva N = 441, n (%)	Baltimore N = 142, n (%)	Milan N = 126, n (%)	Paris N = 103, n (%)	p-value
Access to COVID-19 vaccination	697 (86.4)	377 (86.1)	116 (82.3)	110 (88.0)	94 (91.3)	0.219
Missing values	5	3	1	1	0	
Demand for COVID-19 vaccination	327 (41.2)	168 (39.0)	79 (59.0)	65 (52.0)	15 (14.6)	< 0.001
	19	10	8	1	0	
COVID-19 exposure						
COVID-19 infection (self)	114 (14.1)	62 (14.1)	32 (22.5)	11 (8.7)	9 (8.8)	0.003
Missing	3	2	0	0	1	
COVID-19 infection (household)	129 (16.1)	74 (17.0)	35 (25.2)	17 (13.5)	3 (2.9)	< 0.001
Missing values	9	6	3	0	0	
Clinical risk factors for severe COVID-19 infection						
Cardiovascular disease	109 (13.7)	46 (10.8)	14 (10.1)	34 (27.0)	15 (14.6)	< 0.001
Diabetes	85 (10.7)	21 (4.9)	27 (19.4)	13 (10.3)	24 (23.3)	< 0.001
Weight excess	79 (9.9)	29 (6.8)	22 (15.8)	16 (12.7)	12 (11.7)	0.010
Chronic lung disease	40 (5.0)	24 (5.6)	1 (0.7)	11 (8.7)	4 (3.9)	0.022
Chronic kidney disease	29 (3.7)	15 (3.5)	8 (5.8)	5 (4.0)	1 (1.0)	0.272

≥ 1 co-morbidity	234 (29.5)	96 (22.5)	52 (37.4)	57 (45.2)	29 (28.2)	< 0.001
Missing values	18	15	3	0	0	
Views on COVID-19 risks and vaccination						
High self-perceived risk of severe COVID-19 infection	208 (26.2)	95 (22.0)	35 (25.7)	42 (33.9)	36 (35.0)	0.008
Missing values	18	10	6	2	0	
Positive views on vaccination in general	605 (77.3)	300 (70.6)	126 (94.0)	98 (79.0)	81 (81.0)	< 0.001
Missing values	29	16	8	2	3	
Positive views on COVID-19 vaccination	445 (56.5)	218 (51.1)	104 (77.6)	79 (63.7)	44 (42.7)	< 0.001
Missing values	24	14	8	2	0	
Sources of information about COVID-19 vaccines						
Traditional media (TV, radio, web)	626 (79.3)	329 (76.9)	109 (82.0)	104 (83.2)	84 (81.6)	0.309
Social media	361 (45.8)	189 (44.2)	36 (27.1)	56 (44.8)	80 (77.7)	< 0.001
Community networks	214 (27.1)	99 (23.1)	6 (4.5)	34 (27.2)	75 (72.8)	< 0.001
Other	33 (4.2)	25 (5.8)	0 (0)	7 (5.6)	1 (1.0)	0.007
Missing values	23	13	9	1	0	

Barriers to and preferred place for vaccination

Although perceptions about accessibility did not vary by city, demand ranged widely and was lowest (14.6%) among participants living in Paris. Respondents who did not believe that COVID-19 vaccination would be available to undocumented migrants reported lack of health insurance or card as the main barrier to access. Overall, most participants who intended to get vaccinated preferred to do so at a hospital (73.5%) (Tables 3 and 4).

Table 3: Perceived barriers to accessing to COVID-19 vaccination in participants mentioning vaccination being not accessible.

	Total N = 110, n (%)	Geneva N = 61, n (%)	Baltimore N = 25, n (%)	Milan N = 15, n (%)	Paris N = 9, n (%)

Lack of insurance/health card (National Health System)	57 (51.8)	32 (52.5)	14 (56.0)	9 (60.0)	2 (22.2)
High cost	25 (22.7)	17 (27.9)	2 (8.0)	3 (20.0)	3 (33.3)
Lack of eligibility to enroll in vaccination program	18 (16.4)	8 (13.1)	1 (4.0)	5 (33.3)	4 (44.4)
Not knowing where to go	27 (24.5)	13 (21.3)	9 (36.0)	3 (20.0)	2 (22.2)
Other reasons	13 (11.8)	6 (9.8)	0 (0)	5 (33.3)	2 (22.2)
Missing values	0	0	0	0	0

Table 4: Preferred place for COVID-19 vaccination.

	Total N = 327, n (%)	Geneva N = 168, n (%)	Baltimore N = 79, n (%)	Milan N = 65, n (%)	Paris N = 15, n (%)
Hospital	236 (73.5)	144 (87.8)	40 (50.6)	39 (60.9)	13 (92.9)
Public health/community clinic	65 (20.2)	31 (18.9)	17 (21.5)	16 (25.0)	1 (7.1)
Private physician	20 (6.2)	4 (2.4)	3 (3.8)	11 (17.2)	2 (14.3)
Pharmacy	37 (11.5)	17 (10.4)	6 (7.6)	9 (14.1)	5 (35.7)
Charity	65 (20.2)	22 (13.4)	16 (20.3)	19 (29.7)	8 (57.1)
Other	10 (3.19)	4 (2.4)	2 (2.5)	4 (6.3)	0 (0)
Missing values	6	4	0	1	1

Factors associated with perceived accessibility of COVID-19 vaccination

In univariate and multivariate analysis, female gender was the only factor positively associated with self-perceived accessibility to COVID-19 vaccination overall while participants originating from the Americas or recruited in Baltimore tended to be more confident about accessibility (Table 5).

When the analysis was conducted at study site level, the strength of association with covariates associated with perceived availability were different in each location (Appendix). For instance, Latin American origin in Geneva and information through social media or community network in Paris showed statistically significant associations.

Table 5: Factors associated with perceived accessibility of COVID-19 vaccination in regression analysis

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p-value	aOR (95% CI)	p- value
Study site Geneva	Reference		Reference	
Baltimore	0.75 (0.45-1.25)	0.276	0.56 (0.30-1.03)	0.063
Milan	1.20 (0.65-2.19)	0.562	1.07 (0.56-2.06)	0.838
Paris	1.70 (0.81-3.54)	0.160	2.24 (0.86-5.83)	0.100
Gender female	1.57 (1.04-2.35)	0.030	1.62 (1.03-2.56)	0.038
Age (per additional year)	1.01 (0.99-1.03)	0.272	1.01 (0.99-1.03)	0.511

Region of origin Europe	Reference		Reference	
Africa	1.82 (0.78-4.23)	0.165	1.64 (0.66-4.05)	0.286
Americas	1.77 (0.90-3.46)	0.095	1.97 (0.93-4.16)	0.075
Eastern Mediterranean	2.56 (0.91-7.25)	0.225	2.13 (0.71-6.36)	0.175
South-East Asia	1.12 (0.40-3.13)	0.827	0.84 (0.25-2.79)	0.773
Western Pacific	1.72 (0.72-4.06)	0.220	1.39 (0.55-3.48)	0.484
≥1 clinical risk factors	1.24 (0.79-1.97)	0.352	1.18 (0.70-2.00)	0.533
High self-perceived risk of severe COVID-19	0.89 (0.55-1.42)	0.615	0.90 (0.54-1.49)	0.681
COVID-19 infection (self)	1.06 (0.60-1.88)	0.841	1.01 (0.52-1.99)	0.968
COVID-19 infection (household)	0.88 (0.51-1.50)	0.637	0.90 (0.47-1.70)	0.737
Positive views on vaccination in general	1.39 (0.88-2.20)	0.158	1.33 (0.74-2.39)	0.336
Positive views on COVID-19 vaccination	1.14 (0.76-1.72)	0.518	1.18 (0.71-1.98)	0.519
Information through traditional media (TV, radio, web)	1.19 (0.73-1.93)	0.494	1.20 (0.69-2.11)	0.515
Information through social media	1.29 (0.85-1.94)	0.234	1.21 (0.75-1.96)	0.427
Information through community network	1.22 (0.76-1.97)	0.409	1.00 (0.58-1.74)	0.998
Information through other source	2.39 (0.57-10.11)	0.236	3.13 (0.70-14.08)	0.137

Factors associated with demand for COVID-19 vaccination

Overall, demand for vaccination was associated with a variety of factors (Table 6). Before adjustment, living in the US and Italy, female gender, older age, comorbidity, perception of being at risk of severe COVID-19, positive views on vaccination including COVID-19 and mentioning traditional media as the main source of information were all associated with more chance to demand the vaccination. On the other hand, living in France and using social media and community networks as the preferred sources of information were negatively associated with demand. After adjustment, increasing age, the presence of co-morbidities, and positive views about vaccination in general and COVID-19 in particular were all significantly associated with increased demand for vaccination, while living in France and relying on community network to get informed were associated with lower demand. Of note, the preference for social media lost its significant negative association with demand after adjustment. Although not statistically significant, there was a trend toward more demand among African migrants.

In Geneva and Baltimore, positive views about vaccines were strongly associated with demand (Appendix). In Paris and Milano, the main predictors were the sources of information. Both social media in Milano and community networks in Paris were negatively associated with demand.

Table 6: Factors associated with demand for COVID-19 vaccination in regression analysis

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p-value	aOR (95% CI)	p-value
Study site Geneva	Reference		Reference	
Baltimore	2.24 (1.51-3.33)	<0.001	0.97 (0.56-1.68)	0.920
Milan	1.70 (1.14-2.54)	0.009	1.18 (0.66-2.09)	0.578
Paris	0.26 (0.15-0.47)	<0.001	0.15 (0.06-0.38)	<0.001
Gender female	1.43 (1.07-1.92)	0.016	1.23 (0.80-1.88)	0.344
Age (per additional year)	1.04 (1.02-1.05)	<0.001	1.02 (1.00-1.04)	0.019
Region of origin Europe	Reference		Reference	
Africa	0.75 (0.38-1.46)	0.396	2.73 (0.93-8.02)	0.069
Americas	1.62 (0.94-2.80)	0.085	0.85 (0.36-1.96)	0.695
Eastern Mediterranean	0.93 (0.45-1.93)	0.852	1.93 (0.63-5.86)	0.247
South-East Asia	0.38 (0.15-1.01)	0.052	0.45 (0.12-1.65)	0.231
Western Pacific	0.90 (0.46-1.78)	0.769	0.69 (0.26-1.87)	0.467
≥ 1 co-morbidity	1.91 (1.40-2.61)	<0.001	1.77 (1.10-2.84)	0.018
High self-perceived risk of severe COVID-19	1.46 (1.06-2.01)	0.019	1.26 (0.81-1.96)	0.315
COVID-19 infection (self)	1.37 (0.92-2.05)	0.124	1.23 (0.66-2.27)	0.514
COVID-19 infection (household)	1.23 (0.84-1.79)	0.292	0.84 (0.48-1.49)	0.557
Positive views on vaccination (general)	32.5 (14.2-74.4)	<0.001	12.9 (5.17-32.22)	<0.001
Positive views on vaccination (COVID-19)	16.70 (11.2-24.8)	<0.001	9.70 (6.08-15.47)	< 0.001
Information through traditional media (TV, radio, web)	2.25 (1.53-3.29)	<0.001	1.28 (0.75-2.18)	0.360
Information through social media	0.47 (0.35-0.62)	<0.001	0.84 (0.55-1.28)	0.410
Information through community network	0.47 (0.33-0.65)	<0.001	0.61 (0.38-1.00)	0.049
Information through other source	0.30 (0.12-0.73)	0.008	0.44 (0.13-1.43)	0.170
Self-perceived accessibility to COVID-19 Vaccination	1.19 (0.78-1.81)	0.421	1.08 (0.61-1.92)	0.799

Discussion

This study shows that during the early phase of the COVID-19 immunization program in four cities in Europe and the US, most undocumented migrants believed the COVID-19 vaccine would be available to them, but fewer intended to get vaccinated. During this period, participants listed traditional media as

the most common source of information, followed by social media and community networks. Although perceptions about vaccination in general were positive, they were much lower for COVID-19 vaccination. We found that factors associated with perceived availability of and demand for COVID-19 vaccination diverged across study sites, reflecting differences in samples, local health policies and cultural preferences. This highlights the importance of collecting data at local level in order to tailor responses. These findings provide insights about the factors underlying vaccine hesitancy among undocumented migrants during the initial phase of the vaccination program and can help strengthen it as currently ongoing as well as inform the early response for future initiatives. Traditional media appears to play an important role at the early stage and positive views about general immunization programs should be leveraged through community engagement and messaging in various languages to address issues of particular concern to undocumented migrants, such as safety of the COVID-19 vaccines, confidentiality, and implications on immigration status.

The high confidence in COVID-19 vaccination access among undocumented migrants is telling given their frequent exclusion from many public health benefits. This is reassuring given the legitimate concern that access to vaccination would be limited for this population. Early in the vaccination roll-out, qualitative research among primarily female migrant farmworkers in the US and migrants with precarious immigration status in the UK showed that misinformation and lack of awareness about entitlements, including access to COVID-19 vaccines, could present substantial barriers to immunization programs.[45,46] In our study, women were more likely to endorse access than men. This could be related to increased familiarity with the vaccination programs and overall health system through the use of reproductive health services and as traditional caregivers for children.[47] Participants thinking vaccine would not be available to them mentioned the lack of registration within the healthcare system as the predominant reason, more than financial, eligibility or practical issues. This may reflect how migrants in precarious legal situation internalize structural barriers restricting their agency to satisfy their essential needs.[48] Of interest, most participants reported hospitals as their preferred place for vaccination. This may reflect concern about vaccine safety requiring specialized care and surveillance and the perception that public hospitals are more accessible and secure regarding the management of personal data than private clinics. Previous studies have indeed shown how migrants used camouflage to avoid detection by immigration authorities and the importance of safe places. [49] The gap between accessibility and demand is concerning. One possible explanation might pertain to the timing of the survey. Indeed, in all study locations, the COVID-19 incidence and death toll had sharply dropped by the beginning of the study which may have lessen the feeling of urgency for vaccination. Additionally, at the same time in all four countries, there were widespread public debates about the mRNA-based vaccines short and long-term safety that may have fueled hesitancy. Indeed, this may contribute to explain the discrepancy between reported confidence in vaccines in general as compared to COVID-19 vaccines in particular. In future studies, longer period of observation may help identify fluctuation on the perception of the risks and therefore of hesitancy associated with epidemiological fluctuations and the adoption by the population of scientific and lay information about new vaccine technologies. In our study, there was regional variability, with the lowest demand among participants from Paris. Information from community networks tended also to be associated with low demand for vaccination and was more common in Paris, highlighting the need for targeted approaches for different communities. In Paris, the level of literacy (though not measured) may have been lower, given that most respondents could not fill in the questionnaire themselves but had to be helped. This would impact on the potential source of information: information through community networks is more easily accessible in case of language barriers. Also, the second most common source of information was social media, in which content is uncontrolled, opening the debate on how to use social media to harness vaccine hesitancy. Higher demand for vaccination among older people and those with co-morbidities is consistent with global trends and may reflect the

risk-benefit calculus for people at higher risk of hospitalization and death from COVID-19. In all four sites, only one quarter to a third of participants reported concern about the risk of a severe infection. These low proportions may be related to the overall young age of participant and likely to the comparable proportion of those reporting suffering multiple chronic infections. Interestingly, high self-perceived risk of COVID-19 or prior COVID-19 infection were not associated with demand for vaccination, perhaps because this includes mild cases of the disease.

Intention to get vaccinated against COVID-19 has evolved over time. The successful implementation of large-scale immunizations programs has encouraged many previously hesitant individuals to get vaccinated, but misinformation and fake news continue to fuel mistrust and slow progress in terms of immunization coverage in many settings. In our study, only two in five individuals reported they would get vaccinated if the COVID-19 vaccine was offered to them. Although comparison with other groups is difficult due to heterogeneity of methods and timing, hesitancy appears to be higher in our sample compared to the general adult population in the countries studied. For example, in a survey conducted in Italy in December 2020, 82% of adults reported willingness to get vaccinated compared to 52% of our study participants from Milan.[50] Similarly, in a survey conducted in France in June 2020, 71.8% of participants reported they would accept vaccination compared to only 14.6% of our Paris participants.[51] An international cross-sectional survey conducted between September 2020 and January 2021, however, showed lower intention to get vaccinated among participants from France (49.2%).[52] Of note, all these surveys were conducted online, with likely bias towards higher educational and socioeconomic status. Specific data on undocumented migrants is very limited, but in a survey conducted in the US in late April 2021, 68% of respondents classified as potentially undocumented reported that they had either been vaccinated or planned to get vaccinated.[53]

This study has several limitations. Participant recruitment was nonrandom and occurred in health facilities serving undocumented migrants, thereby involving a non-representative sample population of neither the health facilities' clients nor undocumented migrants at large, and therefore limiting the generalizability of our findings. Specifically, recruitment in healthcare setting may have biased the perception about vaccine accessibility by selecting people with better ability to navigate the healthcare system. Studies conducted in the community would bring important complementary information to our findings. Moreover, differences in sampling strategies and participants sociodemographic characteristics imply limitations in comparability among locations. Furthermore, the questionnaire was translated in 8 languages and translators were not systematically available during questionnaire administration, hence it is possible that participants speaking a different language had a limited understanding about the questionnaire, thus introducing an information bias and limiting response accuracy. Confidence about access to the COVID-19 vaccine and desire to be vaccinated may differ for undocumented migrants who have not interacted with the health system in their country of residence. Nonetheless, approximately half of respondents in our sample identified lack of health insurance/health card as a major barrier to COVID-19 vaccination. Although concerns about immigration have been shown to dampen healthcare utilization for COVID-19 services among undocumented migrants,[54] we did not specifically ask whether worries about immigration repercussions impacted demand. In our study, public hospitals or clinics were identified as preferred sites for vaccination among those intending to get vaccinated, but we did not collect information about trust in public institutions among vaccine hesitant participants. Finally, for efficiency purpose, we build the questionnaire using a stringent selection of items previously shown to influence vaccine hesitancy but we cannot claim to cover all areas underlying participants' assessment of the risk-benefit balance for COVID-19 vaccination.

In summary, our study showed a substantial gap between undocumented migrants' perceptions about access to COVID-19 vaccines and demand for vaccination. The World Health Organization, UNICEF, the UN High Commissioner for Refugees, the European Centre for Disease Prevention and Control (ECDC) and the Council of Europe have issued recommendations urging access to COVID-19 vaccination to all vulnerable populations, including low-income countries, undocumented migrants, and refugees.[33] Our results show that building trust and confidence in COVID-19 vaccination is as important as promoting access to tackle hesitancy in this group. Information and promotion of vaccination should particularly focus on men, younger migrants and those with low clinical risks highlighting both individual and collective benefits and reassuring about vaccines safety. Given the marginalization and criminalization of undocumented migrants, this may not be simple and requires tailored local solutions. [55] Our data suggests that during the first phase of a new vaccination program as for COVID-19, traditional media is an important source of information and communities need to be engaged to leverage existing confidence in general vaccination programs to reduce hesitancy. Social media play an important role on how migrants balance risks and benefits and could represent an avenue for disseminating objective information and ressources. Community engagement is also important to adequately inform and guide community networks, which can be influential but may undermine vaccination efforts unless equipped with official and verified information. Innovative strategies to foster trust in the equitable access to vaccine for everyone and to ensure a high uptake in all groups though multi-pronged tailored intervention may help better controlling the ongoing COVID-19 pandemic. ,. Future research should include the monitoring of hesitancy in this group over longer periods in order to adapt communication strategies and the impact of health promotion interventions using different channels of communication such as social media and community interventions.

Declaration of interest

Authors declare no conflict of interest.

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Authors' statement

YJ: conceptualization, methodology, supervision and writing - review and editing
KP: conceptualization, methodology and writing - original draft
EG: conceptualization, methodology, and writing - review and editing
JC: conceptualization, methodology, and writing - review and editing
MF: data curation, formal analysis and writing - review and editing
AD: data curation and writing - review and editing
SC: investigation and writing - review and editing
GF: investigation and writing - review and editing
RT: investigation and writing - review and editing
SS: investigation and writing - review and editing

Data statement

The dataset that includes all participants' responses to the questionnaire is available at https://doi.org/10.5281/zenodo.5769319.[dataset][56]

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Rapid survey on the intent to be immunized against Covid-19 amongst undocumented migrants

In order to properly meet your health needs, we would like to hear your opinion on the COVID-19 vaccination. This information is anonymous and confidential.

Please tick the correct answer (s) ☒

1. Gender
    a. ☐ Female
    b. ☐ male
2. Age
3. Country of birth
4. Have you suffered from a COVID-19 infection (one choice)
    a. ☐ No
    b. ☐ Yes probably but I haven't been tested
    c. ☐ Yes and I have been tested
5. If yes, when (month/year)?
6. Has somebody living at the same place as you (family or friend) suffered from a COVID-19 infection (one choice)
    a. ☐ No
    b. ☐ Yes probably but she/he hasn't been tested
    c. ☐ Yes and she/he has been tested
7. Do you have any of the following medical conditions that could put you at risk for severe COVID-19 infection (multiple choices)
    a. ☐ High blood pressure (hypertension) or a cardiac (heart) condition
    b. ☐ Diabetes
    c. ☐ Excessive weight
    d. ☐ Chronic disease of the lungs
    e. ☐ Chronic disease of the kidneys
    f. ☐ No
    g. ☐ I don't know
8. What do you think is the risk to your health related to COVID-19 (multiple choices)
    a. ☐ I think the risk is too low to worry
    b. ☐ I follow the recommendations about protection, this is sufficient to be protected
    c. ☐ I don't think I am at risk of a severe infection
    d. ☐ I already got COVID-19 so there is no more risk

e. ☐ I prefer being infected to develop my own immunity
f. ☐ I am worried about developing a severe form of COVID-19
g. ☐ I don't know

9. Do you believe that migrants/persons in your situation will have access to the COVID-19 vaccines here in Switzerland (one choice)
   a. ☐ Yes
   b. ☐ No
   c. ☐ I don't know

10. If no, for what reasons (multiple choices)
   a. ☐ Lack of health insurance
   b. ☐ High cost
   c. ☐ Lack of right to enroll into immunization programs
   d. ☐ Don't know where to go
   e. ☐ Other reason

11. If the vaccine is offered to you, would you like to get immunized against COVID-19 (one choice)
   a. ☐ Yes, no doubt
   b. ☐ Probably yes
   c. ☐ Probably no
   d. ☐ No
   e. ☐ I haven't decided yet

12. If yes, where could you receive the vaccine (multiple choices)
   a. ☐ Hospital (HUG)
   b. ☐ Private doctor
   c. ☐ Pharmacy
   d. ☐ Community organization, charity
   e. ☐ Public health clinic
   f. ☐ Other

13. What is your point of view about vaccines in general (multiple choices)
   a. ☐ I trust in vaccines
   b. ☐ I believe it will protect me
   c. ☐ I am against vaccines in general
   d. ☐ I prefer alternative remedies

e. ☐ I believe I can resist to infections without vaccines

f. ☐ If I have to suffer an infection, vaccine won't help for that

14. What is your point of view about the COVID-19 vaccines (multiple choices)

a. ☐ I trust the COVID-19 vaccine

b. ☐ I believe it will protect me

c. ☐ I don't trust in vaccines using genetic material

d. ☐ I am afraid of negative effects

e. ☐ I think it won't protect me long enough

f. ☐ I don't want to receive two doses

g. ☐ I already had COVID-19 so I don't think I need it

15. How do you access to information about COVID-19 vaccines (multiple choices)

a. ☐ TV, radio, newspapers in Switzerland

b. ☐ TV, radio, newspapers from my country of origin

c. ☐ Websites of the hospital/health authority in Switzerland

d. ☐ Website of the government in Switzerland

e. ☐ Social media (Facebook, YouTube, Instagram, WhatsApp, etc.)

f. ☐ Friends and relatives

g. ☐ Other

Thank you very much for your participation

Appendix

1. Self-perceived accessibility to vaccination

Regression analysis stratified by study site for factors associated with self-perceived accessibility to COVID-19 immunization programs. The univariate and multivariate analysis were repeated by applying a procedure of multiple imputation for missing values (100 imputations).

Geneva (N=441)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	OR (CI 95%)	p-value
Gender: female	1.36 (0.78-2.35)	0.278	1.20 (0.64-2.27)	0.571
Age (increase by 1 year)	1.01 (0.99-1.04)	0.286	1.01 (0.99-1.04)	0.413
≥1 co-morbidity	1.34 (0.67-2.68)	0.413	1.07 (0.49-2.34)	0.862
High self-perceived risk of COVID-19	0.78 (0.39-1.56)	0.479	1.00 (0.47-2.12)	0.993
COVID-19 infection (self)	1.41 (0.69-2.89)	0.345	0.58 (0.25-1.33)	0.198
COVID-19 infection (household)	1.12 (0.53-2.36)	0.769	1.09 (0.45-2.63)	0.849
Positive views on Immunization (general)	1.66 (0.94-2.94)	0.081	1.68 (0.75-3.78)	0.209
Positive views on Immunization (COVID-19)	1.16 (0.67-2.00)	0.601	0.86 (0.41-1.82)	0.693
Information through traditional media (TV, radio, web)	1.58 (0.86-2.90)	0.137	1.94 (0.95-3.95)	0.069
Information through social media	1.13 (0.65-1.99)	0.664	1.35 (0.70-2.61)	0.377
Information through community network	0.93 (0.49-1.78)	0.837	0.87 (0.43-1.74)	0.689
Information through other source	3.53 (0.47-26.73)	0.222	5.04 (0.62-41.27)	0.132
Region of origin (WHO)				
Europe	Ref.		Ref.	
Africa	1.84 (0.67-5.00)	0.235	1.86 (0.65-5.36)	0.249
Americas	3.17 (1.41-7.15)	0.005	2.68 (1.13-6.35)	0.025
Eastern Mediterranean	3.27 (0.82-13.09)	0.093	2.78 (0.67-11.65)	0.161
Asia	2.09 (0.22-19.86)	0.523	2.61 (0.25-26.82)	0.420
Western Pacific	2.46 (0.97-6.20)	0.057	1.78 (0.65-4.87)	0.260

Baltimore (N=142)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	OR (CI 95%)	p-value
Gender: female	2.29 (0.93-5.66)	0.072	1.70 (0.60-4.80)	0.317
Age (increase by 1 year)	0.97 (0.93-1.02)	0.239	0.96 (0.91-1.01)	0.105
≥1 co-morbidity	1.37 (0.54-3.43)	0.507	1.96 (0.65-5.84)	0.230
High self-perceived risk of COVID-19	0.70 (0.24-2.03)	0.513	2.69 (0.67-10.75)	0.161
COVID-19 infection (self)	0.63 (0.20-2.00)	0.434	3.31 (0.59-18.61)	0.174
COVID-19 infection (household)	0.87 (0.33-2.32)	0.786	0.72 (0.17-2.96)	0.648
Positive views on Immunization (general)	1.50 (0.28-7.90)	0.635	1.28 (0.20-8.11)	0.794
Positive views on Immunization (COVID-19)	1.46 (0.54-3.90)	0.452	2.12 (0.67-6.65)	0.199
Information through traditional media (TV, radio, web)	0.56 (0.15-2.05)	0.380	0.62 (0.09-4.45)	0.638
Information through social media	2.18 (0.69-6.87)	0.182	2.42 (0.49-11.99)	0.278
Information through community network	0.20 (0.04-1.04)	0.056	0.09 (0.01-0.76)	0.027
Information through other source	-		-	
Region of origin (WHO) Europe Africa Americas Eastern Mediterranean Asia Western Pacific	-		-	

Milano (N=126)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	OR (CI 95%)	p-value
Gender: female	3.65 (1.20 - 11.08)	0.023	2.30 (0.38-13.89)	0.317
Age (increase by 1 year)	1.03 (0.99-1.07)	0.191	0.99 (0.94-1.05)	0.759
≥1 co-morbidity	0.93 (0.31-2.74)	0.893	1.34 (0.25-7.27)	0.734
High self-perceived risk of COVID-19	1.86 (0.62-5.55)	0.266	0.41 (0.09-1.86)	0.247
COVID-19 infection (self)	0.72 (0.09-6.04)	0.761	1.06 (0.06-18.00)	0.965
COVID-19 infection (household)	0.58 (0.15-2.32)	0.441	0.40 (0.05-3.08)	0.376
Positive views on Immunization (general)	0.53 (0.11-2.50)	0.421	1.42 (0.13-15.93)	0.774
Positive views on Immunization (COVID-19)	1.24 (0.40-3.67)	0.730	2.14 (0.37-12.58)	0.398
Information through traditional media (TV, radio, web)	1.28 (0.33-5.00)	0.722	-	-
Information through social media	0.67 (0.23-1.98)	0.468	0.38 (0.08-1.94)	0.246
Information through community network	1.03 (0.30-3.47)	0.967	2.43 (0.36-16.58)	0.365
Information through other source	0.80 (0.09-7.18)	0.845	0.10 (0.00-2.12)	0.138
Region of origin (WHO)				
Europe	Ref.		Ref.	
Africa	-	-	-	-
Americas	0.46 (0.38-0.58)	<0.001	0.53 (0.05-5.92)	0.603
Eastern Mediterranean	0.30 (0.22-0.40)	<0.001	1.27 (0.03-50.44)	0.897
Asia	0.01 (0.01-0.01)	<0.001	-	-
Western Pacific	-	-	-	-

Paris (N=103)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	OR (CI 95%)	p-value
Gender: female	1.56 (0.31 -7.98)	0.592	2.93 (0.18-47.09)	0.449
Age (increase by 1 year)	1.03 (0.96-1.11)	0.375	1.09 (0.97-1.24)	0.156
≥1 co-morbidity	1.41 (0.28-7.22)	0.680	0.40 (0.03-6.26)	0.517
High self-perceived risk of COVID-19	0.92 (0.22-3.94)	0.915	0.31 (0.03-3.24)	0.329
COVID-19 infection (self)	-	-	-	-
COVID-19 infection (household)	-	-	-	-
Positive views on Immunization (general)	2.40 (0.54-10.62)	0.248	15.52 (0.76-316.86)	0.075
Positive views on Immunization (COVID-19)	1.55 (0.37-6.56)	0.554	1.41 (0.11-17.50)	0.788
Information through traditional media (TV, radio, web)	0.53 (0.06-4.49)	0.559	0.15 (0.00-5.14)	0.293
Information through social media	0.99 (0.19-5.14)	0.994	51.34 (1.02-2576.27)	0.049
Information through community network	3.86 (0.96-15.59)	0.058	10.37 (1.25-86.27)	0.030
Information through other source	-	-	-	-
Region of origin (WHO)				
Europe	Ref.		Ref.	
Africa	-	-	4.06 (0.06-11.31)	0.513
Americas	1.00 (0.02-50.40)	1.000	0.03 (0.00-11.31)	0.251
Eastern Mediterranean	13.5 (0.60-305.29)	0.102	15.73 (0.26-936.44)	0.186
Asia	24 (0.79-732.38)	0.068	94.05 (0.54-16348.27)	0.084
Western Pacific	-	-	-	-

2. Demand for COVID-19 vaccination

Regression analysis stratified by study site for factors associated with demand for COVID-19 immunization programs. The univariate and multivariate analysis were repeated by applying a procedure of multiple imputation for missing values (100 imputations).

Geneva (N=441)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	OR (CI 95%)	p-value
Gender: female	1.08 (0.72-1.62)	0.709	1.23 (0.69-2.18)	0.484
Age (increase by 1 year)	1.03 (1.01-1.05)	0.001	1.02 (1.00-1.05)	0.068
≥1 co-morbidity	1.56 (0.98-2.49)	0.060	1.69 (0.84-3.37)	0.138
High self-perceived risk of COVID-19	1.41 (0.89-2.25)	0.143	1.22 (0.66-2.25)	0.516
COVID-19 infection (self)	1.06 (0.61-1.84)	0.826	0.81 (0.37-1.79)	0.610
COVID-19 infection (household)	1.12 (0.67-1.86)	0.673	1.13 (0.55-2.35)	0.736
Positive views on Immunization (general)	29.26 (11.63-73.60)	<0.001	10.82 (3.81-30.72)	<0.001
Positive views on Immunization (COVID-19)	16.11 (9.60-27.02)	<0.001	8.64 (4.69-15.90)	<0.001
Information through traditional media (TV, radio, web)	1.49 (0.92-2.39)	0.103	0.91 (0.46-1.79)	0.786
Information through social media	0.66 (0.45-0.98)	0.041	0.84 (0.48-1.48)	0.553
Information through community network	0.96 (0.60-1.52)	0.857	0.92 (0.50-1.69)	0.783
Information through other source	0.37 (0.14-1.01)	0.052	0.56 (0.15-2.09)	0.388
Region of origin (WHO)				
Europe	Ref.		Ref.	
Africa	0.98 (0.41-2.35)	0.964	2.16 (0.61-7.71)	0.235
Americas	1.22 (0.60-2.47)	0.586	0.79 (0.29-2.14)	0.641
Eastern Mediterranean	1.74 (0.64-4.69)	0.278	2.09 (0.53-8.33)	0.294
Asia	-	-	0.59 (0.09-3.78)	0.580
Western Pacific	1.01 (0.46-2.22)	0.987	0.61 (0.20-1.86)	0.385
Self-perceived accessibility to COVID-19 Immunization	1.29 (0.72-2.30)	0.392	1.20 (0.55-2.65)	0.647

Baltimore (N=142)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	OR (CI 95%)	p-value
Gender: female	1.23 (0.59-2.60)	0.582	1.75 (0.59-5.20)	0.311
Age (increase by 1 year)	1.07 (1.02-1.11)	0.002	1.03 (0.97-1.09)	0.282
≥1 co-morbidity	2.56 (1.24-5.67)	0.012	2.10 (0.73-6.08)	0.169
High self-perceived risk of COVID-19	0.65 (0.28-1.49)	0.308	1.30 (0.38-4.50)	0.676
COVID-19 infection (self)	0.67 (0.28-1.58)	0.360	2.57 (0.53-12.57)	0.244
COVID-19 infection (household)	0.70 (0.32-1.51)	0.364	0.37 (0.09-1.50)	0.163
Positive views on Immunization (general)	-	-	-	-
Positive views on Immunization (COVID-19)	15.63 (5.02-48.63)	<0.001	17.17 (4.74-62.16)	<0.001
Information through traditional media (TV, radio, web)	4.82 (1.82-12.75)	0.002	7.12 (0.83-61.16)	0.074
Information through social media	0.49 (0.22-1.06)	0.069	2.40 (0.34-16.98)	0.381
Information through community network	0.13 (0.01-1.13)	0.064	0.09 (0.00-1.71)	0.108
Information through other source	-		-	-
Region of origin (WHO) Europe Africa Americas Eastern Mediterranean Asia Western Pacific	-	-	-	-
Self-perceived accessibility to COVID-19 Immunization	1.43 (0.60-3.43)	0.419	1.20 (0.55-2.65)	0.647

Milano (N=126)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	OR (CI 95%)	p-value
Gender: female	0.93 (0.44-1.96)	0.842	1.03 (0.17-6.35)	0.978
Age (increase by 1 year)	1.02 (1.00-1.05)	0.100	1.02 (0.97-1.07)	0.509
≥1 co-morbidity	1.30 (0.64-2.63)	0.469	1.51 (0.36-6.39)	0.574
High self-perceived risk of COVID-19	0.73 (0.34-1.55)	0.410	3.09 (0.68-14.01)	0.144
COVID-19 infection (self)	0.38 (0.10-1.50)	0.167	1.44 (0.11-19.19)	0.782
COVID-19 infection (household)	1.36 (0.48-3.84)	0.559	1.37 (0.17-10.75)	0.764
Positive views on Immunization (general)	-	-	-	-
Positive views on Immunization (COVID-19)	48.21 (13.36-174.0)	<0.001	-	-
Information through traditional media (TV, radio, web)	4.42 (1.51-12.97)	0.007	0.08 (0.00-2.22)	0.136
Information through social media	0.44 (0.22-0.91)	0.027	0.11 (0.02-0.48)	0.004
Information through community network	0.76 (0.34-1.66)	0.487	1.83 (0.37-9.12)	0.463
Information through other source	0.14 (0.02-1.19)	0.072	0.35 (0.01-14.84)	0.583
Region of origin (WHO)				
Europe	Ref.		Ref.	
Africa	4.00 (3.34-4.80)	<0.001	-	-
Americas	1.64 (1.49-1.81)	<0.001	0.57 (0.08-4.27)	0.584
Eastern Mediterranean	1.78 (1.50-2.11)	<0.001	3.02 (0.12-76.35)	0.503
Asia	0.27 (0.21-0.34)	<0.001	0.02 (0.00-4.19)	0.148
Western Pacific	-	-	-	-
Self-perceived accessibility to COVID-19 Immunization	1.29 (0.72-2.30)	0.392	1.02 (0.97-1.07)	0.509

Paris (N=103)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	OR (CI 95%)	p-value
Gender: female	2.33 (2.09-2.61)	<0.001	2.43 (0.31-19.09)	0.397
Age (increase by 1 year)	1.06 (1.05-1.06)	<0.001	1.08 (0.99-1.18)	0.095
≥1 co-morbidity	3.65 (3.26-4.08)	<0.001	1.63 (0.12-21.77)	0.712
High self-perceived risk of COVID-19	0.30 (0.26-0.33)	<0.001	3.21 (0.36-28.34)	0.294
COVID-19 infection (self)	1.40 (1.13-1.74)	0.002	9.40 (0.36-245.25)	0.178
COVID-19 infection (household)	-	-	-	-
Positive views on Immunization (general)	3.65 (0.45-29.65)	0.225	1.33 (0.04-47.30)	0.876
Positive views on Immunization (COVID-19)	3.18 (2.83-3.57)	<0.001	2.70 (0.34-21.30)	0.346
Information through traditional media (TV, radio, web)	-	-	-	-
Information through social media	0.51 (0.46-0.58)	<0.001	1.91 (0.20-18.04)	0.574
Information through community network	0.18 (0.16-0.21)	<0.001	0.09 (0.01-0.61)	0.014
Information through other source	-	-	-	-
Region of origin (WHO) Europe Africa Americas Eastern Mediterranean Asia Western Pacific	-	- -	-	-
Self-perceived accessibility to COVID-19 Immunization	0.16 (0.14-0.19)	< 0.001	0.05 (0.00-0.58)	0.017

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

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		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			

Study design	#4	Present key elements of study design early in the paper	4
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	5
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	6
Bias	#9	Describe any efforts to address potential sources of bias	5
Study size	#10	Explain how the study size was arrived at	6
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	6
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	6
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	7
Statistical methods	#12c	Explain how missing data were addressed	7
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	n/a
Statistical methods	#12e	Describe any sensitivity analyses	7

Results

Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	7
Participants	#13b	Give reasons for non-participation at each stage	n/a
Participants	#13c	Consider use of a flow diagram	n/a
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	7
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	8
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	8
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	n/a
Main results	#16b	Report category boundaries when continuous variables were categorized	n/a
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	9-12
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Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	13

Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	13
Generalisability	#21	Discuss the generalisability (external validity) of the study results	13
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14

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COVID-19 vaccine hesitancy among undocumented migrants during the early phase of the vaccination campaign: a multi-centric cross-sectional study

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COVID-19 vaccine hesitancy among undocumented migrants during the early phase of the vaccination campaign: a multi-centric cross-sectional study

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Abstract

Study objectives:
The marginalization of undocumented migrants raises concerns about equitable access to COVID-19 vaccination. This study aims to describe migrants' hesitancy about the COVID-19 vaccination during the early phase of the vaccination campaign.

Setting:
This multi-centric cross-sectional survey was conducted in health facilities providing care to undocumented migrants in the United States, Switzerland, Italy, and France in February-May 2021.

Participants:
Eligibility criteria included age >16, being of foreign origin and living without valid residency permit in the country of recruitment. A convenience sample of minimum 100 patients per study site was targeted.

Primary and secondary outcome measures:
Data were collected using an anonymous structured questionnaire. The main outcomes were perceived access to the local COVID-19 vaccination program and demand for vaccination.

Results:
Altogether, 812 undocumented migrants participated (54.3% Geneva, 17.5% Baltimore, 15.5% Milano and 12.7% Paris). Most (60.9%) were women. The median age was 40 years (range 17-76). Participants originated from the Americas (55.9%), Africa (12.7%), Western Pacific (11.2%) Eastern Mediterranean (7.9%), Europe (7.6%) and South-East Asia (4.7%). Overall, 14.1% and 26.2% of participants, respectively, reported prior COVID-19 infection and fear of developing severe COVID-19 infection. Risk factors for severe infection were frequently reported (29.5%). Self-perceived accessibility of COVID-19 vaccination was high (86.4%), yet demand was low (41.1%) correlating with age, co-morbidity, and views on vaccination which were better for vaccination in general (77.3%) than vaccination against COVID-19 (56.5%) Participants mainly searched for information about vaccination in the traditional and social media.

Conclusions:
We found a mismatch between perceived accessibility and demand for the COVID-19 vaccination. Public health interventions using different communication modes should build on trust about vaccination in general to tackle undocumented migrants' hesitancy for COVID-19 vaccination with a specific attention to men, younger migrants and those at low clinical risk for severe infection.

Trial registration: no

Strengths and limitations

- The study included undocumented migrants, a hard to reach population, in four countries
- Efforts were made to overcome language, trust and literacy barriers to participation
- The number of participants differed in every study sites

Introduction

It is estimated that between 3.9 and 4.8 million undocumented migrants live in Europe and 10.5 million in the United States (US).[1-3] Economic opportunities, integration policies, and the rights and benefits

afforded to undocumented migrants vary by host country. However, challenges including language barriers, fear of deportation, poverty, housing precariousness, and limited access to healthcare and workplace protections, are common experiences for most undocumented migrants.

Although undocumented migrants represent less than 1% of Europe's and 3.2% of the US total population, emerging evidence points to the devastating impact of COVID-19 in this group. In high-income countries, migrants have high risk of COVID-19 infection, morbidity, and mortality.[4] Although COVID-19 outcomes by specific immigration status are rarely available, surrogate markers (e.g. language, country of origin, housing status, health insurance eligibility, and demographics) suggest that undocumented migrants are at particularly high risk.[4-13] Community and health facility-based studies in Europe and the US showed exceptionally high SARS-CoV-2 positivity rates among foreign-born or limited English proficiency patients.[7,8,14,15] In the US, COVID-19 case rates were highest in counties with large immigrant communities, and the correlation was stronger in areas with more Central Americans, a group with high poverty levels and irregular migrant status .[1,12,16] In addition, there is evidence of poor outcomes due to delayed presentation to care among undocumented migrants.[4,6,10,17,18] Mortality data by migrant status is limited, but what is available shows that compared to native-born citizens, migrants to Europe and the US, particularly those from low and middle-income countries, have higher excess all-cause and COVID-19 mortality. [19-23]

Undocumented migrants play an essential role in the global economy but rely heavily on informal and low-wage labor with limited occupational protections. Mitigation strategies to reduce the social, economic and health impact of the COVID-19 pandemic frequently exclude undocumented migrants. Without a social safety net, many continued to work at the peak of the pandemic in high-risk essential jobs, such as logistics, manufacturing, domestic and care activities, construction, and the food processing industry.[11,24,25] Several European countries provided food assistance to migrants during lockdown, and a few further extended benefits. For example, Ireland implemented a system to pay unemployment benefits to undocumented migrants who lost their jobs, and Portugal granted temporary citizenship rights to migrants.[26] The suspension of exclusionary immigrant policies, however, was not uniform and there were many unmet needs and many vulnerable undocumented migrants fell into extreme poverty.[26] A survey conducted in Switzerland in April 2020 showed that almost one in six migrants had experienced hunger during the first lockdown.[27]

Furthermore, long-standing anti-immigrant policies and mistrust of governmental institutions have not been eased during the pandemic, and pre-existing legal, socio-economic, and linguistic barriers to social and health services have exacerbated the impact of COVID-19 among undocumented migrants. [28,29] Although countries deployed health services for COVID-19 without eligibility restrictions based on migration status, no specific measure has been implemented to facilitate access for undocumented migrants who already tended to underutilize social and health services even before the pandemic.[30,31] As a result, pre-existing barriers to accessing health and social services are exacerbated by the pandemic and likely lead to delaying life-saving care for many.[6,10,11,27]

The rapid development of effective COVID-19 vaccines was an unprecedented scientific achievement, but equitable vaccine distribution is a major challenge worldwide. Undocumented migrants and other socially disadvantaged populations have faced significant hurdles to get vaccinated, including digital, transportation, and health system navigation barriers. The European Centre for Disease Prevention and Control (ECDC) and the Council of Europe have called for tailored vaccination programs for undocumented migrants that are free from immigration control enforcement activities,[32] but only a few national immunization plans explicitly include provisions for undocumented migrants, or address potential

barriers, such as langauge proficiency or identification requirements.[33,34] In addition, the willingness and hesitancy of individuals, including undocumented migrants, to get immunized depends on a variety of factors, such as self-perceived risks and severity of illness; confidence in the safety and effectiveness of the vaccine; trust in medical, govermental, or pharmaceutical institutions; behavioral and social processes (e.g. awareness, information, education, social norms, networks, and media). The objective of this multi-centric study conducted in the early phase of COVID-19 immunization programs was to explore undocumented migrants' hesitancy about COVID-19 vaccine.

Methods

Design

This multi-centric cross-sectional survey was conducted from mid-February to late May 2021 in four facilities providing medical care to undocumented migrants in Switzerland, the United States, Italy, and France during the early phase of the vaccination campaign (February to May 2021).

Setting

The four study sites are part of an informal network of health institutions providing care to undocumented migrants which started to share experiences and good practices during the early phase of the COVID-19 pandemic.

Geneva, Switzerland

Geneva (population 500,000) hosts an estimated 10,000 to 15,000 undocumented migrants, predominantly women from Latin America, the Philippines and South-Eastern Europe who are active in the domestic and care industry.[35] While potentially eligible to purchasing the mandatory health insurance to access to medical care, less than 10% are actually insured because of financial and administrative barriers. The Geneva University Hospital acts as the main port of entry into the healthcare system for undocumented migrants and other underserved groups of population, providing the full range of preventive, curative and rehabilitation health services.[36] While the Swiss Federal Government has decided upon the universal access to COVID-19 vaccination to all residents irrespective of their legal status in early 2021, the policy implementation has been delayed at Canton level and Geneva was the first Canton to officially integrate undocumented migrants into the vaccination program in May 2021.[37] At the beginning of the study, the COVID-19 incidence and mortality in Canton Geneva were at their lowest since October 2020. There was then a mild resurgence of new cases not associated with increased mortality that peaked in April before coming back to its baseline in May. The vaccination campaign started on December 28, 2020. Two vaccines were available, BNT162b2 mRNA (Pfizer/BioNTech) and mRNA-1273 (Moderna). In the first two months, vaccination was limited to high risk groups and it became available to all adults in early March 2021. By the end of the study, 37% of the population had received at least one dose. No additional public restrictions were imposed during the study period.

Milan, Italy

According to available estimates, there are currently 517,000 undocumented migrants in Italy.[38] Disaggregated estimates at city level including for Milan are not readily available. However, Milan is the economic center and the most populous region in Italy, hence likely to host a large population of

undocumented migrants. In principle, the National Health Service system is based on a universalistic model providing healthcare free of charge at the point-of-use against payment of standard flat fees with waivers based on socio-economic criteria and is decentralized at regional level for both policy and service delivery aspects. Access to the NHS requires a valid health card, which is issued based on residency status. As a result, undocumented migrants do not have access to the NHS. To address this fundamental legal and administrative barrier, the NHS provides a temporary access code, which allows access to emergency care and essential services including maternity and vaccination services. In practice, undocumented migrants face barriers even to obtain a temporary access code and rely on charities for accessing healthcare. Among them, ''Opera San Francesco per i Poveri'' is a faith-based charity operating a large size health clinic in Milan providing free-of-charge outpatient healthcare including consultations, diagnostics, and therapy for socially disadvantaged population groups including undocumented migrants. For COVID-19 vaccination, the NHS procures and distributes vaccines and consumables, while the regional health system administers them through a client-initiated online booking system requiring a valid health card. As of 25th June 2021, the Lombardy Region, with Milan as the chief lieu, granted eligibility for online booking to undocumented migrants with a temporary access code. Charities have mobilized to provide individual support to facilitate administrative, linguistic and practicality challenges. At study inception, COVID-19 incidence and mortality were persistently elevated in Italy. The Lombardy Region, with Milan as its chief-lieu, continued to account for the highest toll in-country. Restrictions including lockdown continued to be implemented in a modular way according to local epidemiology. The national immunization campaign kicked off officially just before the end of 2020, targeting the health workforce and the elderly in hospices; however, it struggled to pick up pace until summer 2021 and only 1.2% of total target population was fully immunized at study inception. Initially, the campaign used BNT162b2 mRNA, then mRNA-1273, ChAdOx1 nCoV-19 AZD1222 (Astra-Zeneca), and finally added JNJ-78436735 (Johnson & Johnson) vaccines, the latter having been prioritized for hard-to-reach population groups including undocumented migrants.

Baltimore, USA

Baltimore City is an emergent destination for migrants from Latin America.[39] An estimated 20,000 foreign-born Latin Americans live in the city and approximately 13,500 (67%) are not citizens. Migrants from Mexico and Central America have higher non-citizen status (> 80%), low educational attainment (50% with less than high school education), and high rates (70%) of limited English proficiency.[40] In the US, the COVID-19 vaccine is freely available to all, regardless of immigration or insurance status, and the Department of Homeland Security has explicitly stated that immigration enforcement activities will not be conducted at vaccination site.[41] In the early stages of the COVID-19 immunization program, the state of Maryland implemented a phased distribution plan and the vaccine was not available to the general population until April 27, after data collection for this study was completed. The Access Program, Johns Hopkins Medicine in Baltimore, Maryland (TAP) acts as the main port of entry into the Johns Hopkins Health System. Patients are enrolled in TAP if they are low income (<200% federal poverty line) and are ineligible to enroll in Medicaid or subsidized health insurance because of their irregular immigration status. In Baltimore City, cases of COVID-19 in February of 2021 were the lowest since October 2020, but by March 2021, a fourth wave of COVID-19 emerged which peaked on April 10, 2021. COVID-19 vaccine administration began on December 14, 2020 in a phased approach which sequentially prioritized first responders, the elderly and those with underlying health conditions. The vaccine became available to the general population on April 27, 2021. Three COVID-19 vaccines authorized in the US for Emergency Use or FDA-approved were available for vaccination programs: BNT162b2 mRNA, mRNA-1273 and JNJ-78436735.

Paris, France

Avicenne University hospital is located in the Department of Seine Saint Denis in the North-East of Paris. The Department is historically a place where migrants use to be provided social lodging after the Second World War (mainly Sub-Saharan Africa and North-African communities). It is estimated that more than 30% of the population is constituted of immigrants, with recently an additional wave of migrants from South Asia. Moreover, the majority of undocumented migrants in metropolitan France (around 400.000) tend to be concentrated in this Department. Undocumented migrants in France have access to health via State Medical Aid, an insurance coverage for individuals with no right to National Health Insurance. Those without any coverage may access health care via specific units created for uninsured persons (PASS, Permanence d'accès aux soins), located in hospitals principally. Avicenne University Hospital receives uninsured persons via this unit on a daily basis. In France, all eligible persons are entitled to Covid19 vaccination, as per government declaration. In Paris region, incidence of COVID-19 mid-February 2021 was already high at 237/100,000 inhabitants, and quickly increased further. A third lockdown was ordered on March 18, when incidence was at 426/100,000. The incidence peaked at the end of April, at 682/100,000, and slowly decreased. The survey hence took place about one month before the lockdown when virus circulation was already quite high, with a regional curfew in place since mid-January. The rate of study site enrollment was further affected by the lockdown and the increased police controls. COVID-19 vaccine national campaign began on December 27, 2020 in a phased approach which first prioritized the elderly, and those with underlying health conditions. The vaccine became available to the general population on January 18, 2021, while its uptake was very slow during the first weeks. The four COVID-19 vaccines authorized in France for were BNT162b2 mRNA, mRNA-1273, ChAdOx1 nCoV-19 AZD1222 and JNJ-78436735.Participants

Eligibility criteria were age equal or above 16 and living as a foreigner without valid residency permit (undocumented) in the country of recruitment. Participants were recruited upon spontaneous presentation (walk-in) to one of the participating health facilities.

We used several strategies to reduce the risk of recruitment and measurement bias by addressing the main barriers limiting undocumented migrants' participations in health programs such as fear of personal data misuse and socio-cultural factors. All consecutive patients consulting at the four health facilities were informed about the study orally and with written material in different languages. We explained that the questionnaire was anonymous, and that no identifying information was collected considering the frequent fear of undocumented migrants to disclose personal information. The questionnaire was translated in French, Spanish, Italian, Portuguese, Arabic, English, Tagalog, Albanian, Ukrainian, and Russian to match with the main languages spoken by migrants visiting the participating health facilities. Participants were proposed the support of research assistants competent in various languages to fill the questionnaire to overcome potential difficulties in reading and understanding the questions.

Data source and variables

We designed a 15-item questionnaire (Supplementary material) based on UNICEF and WHO guidance toolkit for COVID-19 vaccination demand,[42, 43] and a European Centre for Diseases Control (ECDC) document exploring vaccine hesitancy.[44] Our main outcome of interest was COVID-19 vaccine hesitancy explored through two main perspectives, perception about vaccination accessibility and the drivers and barriers for demands. Accessibility was investigated using the question: "Do you believe that migrants in your [legal] situation will have access to the COVID-19 vaccination?" with "yes", "no", and "I don't know" as possible responses; we dichotomized ''yes'' and ''I don't know" versus 'no'' in order to determine the

proportion of participants perceiving that the vaccination would not be inaccessible. We further investigated the type of barrier in those responding "no". Demand was investigated using the question: "If the vaccine was offered to you, would you like to get immunized against COVID-19?". Responses to the latter question included "yes no doubt", "probably yes", "probably no", "no", "I don't know yet". In the analysis, we dichotomized ''yes no doubt" versus all other response to determine the proportion of vaccine-hesitant respondents, based on the definition of vaccine hesitance as the reluctance or refusal to vaccinate despite the availability of vaccines along a continuum with a broad spectrum of attitudes and intentions from active demand to passive acceptance, vaccine hesitancy, and refusal of all vaccines[44]. We explored enabling and barriers factors for vaccine accessibility and demand such as demographic characteristics, self-reported clinical risk factors for severe SARS-CoV-2 infection, previous infection with SARS-CoV-2 (self and/or household), self-perceived health risks with COVID-19, views about vaccination in general and COVID-19 vaccination in terms of safety and efficacy (both dichotomized as positive versus negative), desirable place of vaccination, and finally the main sources of information about COVID-19 vaccine (traditional media, social media, and community networks). The questionnaire was pretested in 10 participants before being implemented in all study sites.

Study size

In absence of pre-existing hypothesis regarding the distribution of responses to the two main outcomes, considering the difference in the number of monthly visits in each site and the uncertainties about migrants' willingness to engage into the study in the different sites, we pragmatically set a minimal sample size of 100 participants per study site to be reached within the pre-defined study period.

Patient and Public Involvement

This study was informed by patients expressing interest and concerns to healthcare workers about COVID-19 vaccine accessibility and safety in the four study sites.

Statistical analysis

Categorical data are presented as proportions with percentages and non-normally distributed continuous variable as median with interquartile range (IQR). We compared the distribution of variables in the four study sites using the Kruskal-Wallis test for non-normally distributed variables and the chi-square test or the Fisher's exact test, as appropriate. The significance level was set at 0.05.

We performed both univariate and multivariate logistic regression analysis to identify factors associated with the two main outcomes. Odds ratios were estimated through multivariate logistic regression models, which were mutually adjusted with all covariates in the models. Missing values, which ranged from 0.2% to 3.6% of the total study size, were imputed by using a multiple (n=100) imputation approach. Briefly, multiple imputation is a Bayesian method that allows to take into account incomplete cases (i.e. observations with any missing data) with a two-step approach. First, this method creates multiple imputed datasets, in which missing values are replaced by imputed values. These are sampled from their predictive distribution based on the observed data. The imputation procedure fully accounts for the uncertainty in predicting the missing values by conferring appropriate variability into the multiple imputed values. Second, standard statistical methods are used to fit the model of interest to each of the imputed datasets. Estimates associated to each of the imputed datasets differ because of the variation introduced in the imputation of the missing values (stage 1), and they are, then, average together to give overall estimated associations. Valid inferences are obtained because they are based on the average of the distribution of the missing data given the observed data, and results were reported as odds ratios (OR) along with their 95% confidence intervals (CI). All analysis were performed using SAS 9.4 (Cary, NC, USA).

Ethical review

The John Hopkins University (IRB00252774), Geneva Canton (CCER 2021-0246), and the University of Milan-Bicocca (138AQ-38183) ethical boards provided clearance for this survey. In France, the INSERM review board (IRB00003888) considered this study to be exempted of ethical clearance given the nature of the survey. The study was registered with the Office of the data protection (DPO) of Sorbonne Paris Nord University. All participants gave oral informed consent to participate.

Role of the funding source

The funders had no role in study design, or in data collection, analysis or interpretation.

Results

Participants' characteristics

A total of 812 individuals completed the survey, 441 (54.3%) in Geneva, 142 (17.5%) in Baltimore, 126 (15.5%) in Milan, and 103 (12.7%) in Paris. The median age was 40.1 years (range 17-76) with a predominance of female respondents (60.9%), but gender distribution varied by city and, notably, 69.9% of participants in Paris were male (Table 1). They mainly originated from the Americas (55.9%), Africa (12.7%) and the Western Pacific regions (11.2%). Participants born in the Americas accounted for all the respondents in Baltimore, over half in Geneva and Milan, but only 1.9% in Paris, which had the largest representation of African migrants.

Table 1: Sociodemographic characteristics of the participants (n=812).

	Total N = 812, n (%) or median (IQR)	Geneva N = 441, n (%) or median (IQR)	Baltimore N = 142, n (%) or median (IQR)	Milan N = 126, n (%) or median (IQR)	Paris N = 103, n (%) or median (IQR)	p-value
Female gender	492 (60.9)	279 (63.4)	98 (70.0)	84 (67.2)	31 (30.1)	< 0.001
Missing values	4	1	2	1	0	
Age	39 (16)	39 (17)	40 (13)	41 (20)	35 (16)	0.001
Missing values	2	1	0		1	
Region of origin						0.001
Africa	103 (12.7)	52 (11.8)	0 (0)	8 (6.4)	43 (41.8)	
Americas	454 (55.9)	227 (51.5)	142 (100)	83 (65.9)	2 (1.9)	
Eastern Mediterranean	64 (7.9)	28 (6.4)	0 (0)	7 (5.6)	29 (28.2)	
Europe	62 (7.6)	39 (8.8)	0 (0)	21 (16.7)	2 (1.9)	
Asia	38 (4.7)	7 (1.6)	0 (0)	6 (4.8)	25 (24.3)	
Western Pacific	91 (11.2)	88 (20.0)	0 (0)	1 (0.8)	2 (1.9)	
Missing values	0	0	0	0	0	

Accessibility and demand for vaccination and risk factors for severe infection

The vast majority (86.4%) of participants perceived that the COVID-19 vaccination would be accessible to undocumented migrants, but a lower proportion (41.2%) reported they would get vaccinated against COVID-19 (Table 2). Approximately one third (29.5%) of participants reported at least one chronic co-morbidity that could predispose to severe COVID-19 infection, 14.1% reported prior COVID-19 infection, and 26.2% worried about developing severe COVID-19 (Table 2). In all cities, perceptions about vaccination in general were more favorable than about COVID-19 vaccination overall, more than three quarters (77.3%) of respondents had positive views on vaccination in general, compared to (56.5%) about COVID-19 vaccination. Traditional media was the most common source of information about COVID-19 vaccination, followed by social media. Community networks were a common source of information among participants in Paris (72.8%), but less so among participants in other cities.

Table 2: Undocumented migrants' perceived accessibility to and demand for COVID-19 vaccine with related enabling and barrier factors

	Total N = 812, n (%)	Geneva N = 441, n (%)	Baltimore N = 142, n (%)	Milan N = 126, n (%)	Paris N = 103, n (%)	p-value
Access to COVID-19 vaccination	697 (86.4)	377 (86.1)	116 (82.3)	110 (88.0)	94 (91.3)	0.219
Missing values	5	3	1	1	0	
Demand for COVID-19 vaccination	327 (41.2)	168 (39.0)	79 (59.0)	65 (52.0)	15 (14.6)	< 0.001
	19	10	8	1	0	
COVID-19 exposure						
COVID-19 infection (self)	114 (14.1)	62 (14.1)	32 (22.5)	11 (8.7)	9 (8.8)	0.003
Missing	3	2	0	0	1	
COVID-19 infection (household)	129 (16.1)	74 (17.0)	35 (25.2)	17 (13.5)	3 (2.9)	< 0.001
Missing values	9	6	3	0	0	
Clinical risk factors for severe COVID-19 infection						
Cardiovascular disease	109 (13.7)	46 (10.8)	14 (10.1)	34 (27.0)	15 (14.6)	< 0.001
Diabetes	85 (10.7)	21 (4.9)	27 (19.4)	13 (10.3)	24 (23.3)	< 0.001
Weight excess	79 (9.9)	29 (6.8)	22 (15.8)	16 (12.7)	12 (11.7)	0.010
Chronic lung disease	40 (5.0)	24 (5.6)	1 (0.7)	11 (8.7)	4 (3.9)	0.022

Chronic kidney disease	29 (3.7)	15 (3.5)	8 (5.8)	5 (4.0)	1 (1.0)	0.272
≥ 1 co-morbidity	234 (29.5)	96 (22.5)	52 (37.4)	57 (45.2)	29 (28.2)	< 0.001
Missing values	18	15	3	0	0	
Views on COVID-19 risks and vaccination						
High self-perceived risk of severe COVID-19 infection	208 (26.2)	95 (22.0)	35 (25.7)	42 (33.9)	36 (35.0)	0.008
Missing values	18	10	6	2	0	
Positive views on vaccination in general	605 (77.3)	300 (70.6)	126 (94.0)	98 (79.0)	81 (81.0)	< 0.001
Missing values	29	16	8	2	3	
Positive views on COVID-19 vaccination	445 (56.5)	218 (51.1)	104 (77.6)	79 (63.7)	44 (42.7)	< 0.001
Missing values	24	14	8	2	0	
Sources of information about COVID-19 vaccines						
Traditional media (TV, radio, web)	626 (79.3)	329 (76.9)	109 (82.0)	104 (83.2)	84 (81.6)	0.309
Social media	361 (45.8)	189 (44.2)	36 (27.1)	56 (44.8)	80 (77.7)	< 0.001
Community networks	214 (27.1)	99 (23.1)	6 (4.5)	34 (27.2)	75 (72.8)	< 0.001
Other	33 (4.2)	25 (5.8)	0 (0)	7 (5.6)	1 (1.0)	0.007
Missing values	23	13	9	1	0	

Barriers to and preferred place for vaccination

Although perceptions about accessibility did not vary by city, demand ranged widely and was lowest (14.6%) among participants living in Paris. Respondents who did not believe that COVID-19 vaccination would be available to undocumented migrants reported lack of health insurance or card as the main barrier to access. Overall, most participants who intended to get vaccinated preferred to do so at a hospital (73.5%) (Tables 3 and 4).

Table 3: Perceived barriers to accessing to COVID-19 vaccination in participants mentioning vaccination being not accessible.

	Total	Geneva	Baltimore	Milan	Paris

	N = 110, n (%)	N = 61, n (%)	N = 25, n (%)	N = 15, n (%)	N = 9, n (%)
Lack of insurance/health card (National Health System)	57 (51.8)	32 (52.5)	14 (56.0)	9 (60.0)	2 (22.2)
High cost	25 (22.7)	17 (27.9)	2 (8.0)	3 (20.0)	3 (33.3)
Lack of eligibility to enroll in vaccination program	18 (16.4)	8 (13.1)	1 (4.0)	5 (33.3)	4 (44.4)
Not knowing where to go	27 (24.5)	13 (21.3)	9 (36.0)	3 (20.0)	2 (22.2)
Other reasons	13 (11.8)	6 (9.8)	0 (0)	5 (33.3)	2 (22.2)
Missing values	0	0	0	0	0

Table 4: Preferred place for COVID-19 vaccination.

	Total N = 327, n (%)	Geneva N = 168, n (%)	Baltimore N = 79, n (%)	Milan N = 65, n (%)	Paris N = 15, n (%)
Hospital	236 (73.5)	144 (87.8)	40 (50.6)	39 (60.9)	13 (92.9)
Public health/community clinic	65 (20.2)	31 (18.9)	17 (21.5)	16 (25.0)	1 (7.1)
Private physician	20 (6.2)	4 (2.4)	3 (3.8)	11 (17.2)	2 (14.3)
Pharmacy	37 (11.5)	17 (10.4)	6 (7.6)	9 (14.1)	5 (35.7)
Charity	65 (20.2)	22 (13.4)	16 (20.3)	19 (29.7)	8 (57.1)
Other	10 (3.19)	4 (2.4)	2 (2.5)	4 (6.3)	0 (0)
Missing values	6	4	0	1	1

Factors associated with perceived accessibility of COVID-19 vaccination

In univariate and multivariate analysis, female gender was the only factor positively associated with self-perceived accessibility to COVID-19 vaccination overall while participants originating from the Americas or recruited in Baltimore tended to be more confident about accessibility (Table 5).

When the analysis was conducted at study site level, the strength of association with covariates associated with perceived availability were different in each location (Appendix). For instance, Latin American origin in Geneva and information through social media or community network in Paris showed statistically significant associations.

Table 5: Factors associated with perceived accessibility of COVID-19 vaccination in regression analysis

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p-value	aOR (95% CI)	p- value
Study site Geneva	Reference		Reference	
Baltimore	0.75 (0.45-1.25)	0.276	0.56 (0.30-1.03)	0.063
Milan	1.20 (0.65-2.19)	0.562	1.07 (0.56-2.06)	0.838
Paris	1.70 (0.81-3.54)	0.160	2.24 (0.86-5.83)	0.100

Gender female	1.57 (1.04-2.35)	0.030	1.62 (1.03-2.56)	0.038
Age (per additional year)	1.01 (0.99-1.03)	0.272	1.01 (0.99-1.03)	0.511
Region of origin Europe	Reference		Reference	
Africa	1.82 (0.78-4.23)	0.165	1.64 (0.66-4.05)	0.286
Americas	1.77 (0.90-3.46)	0.095	1.97 (0.93-4.16)	0.075
Eastern Mediterranean	2.56 (0.91-7.25)	0.225	2.13 (0.71-6.36)	0.175
South-East Asia	1.12 (0.40-3.13)	0.827	0.84 (0.25-2.79)	0.773
Western Pacific	1.72 (0.72-4.06)	0.220	1.39 (0.55-3.48)	0.484
≥1 clinical risk factors	1.24 (0.79-1.97)	0.352	1.18 (0.70-2.00)	0.533
High self-perceived risk of severe COVID-19	0.89 (0.55-1.42)	0.615	0.90 (0.54-1.49)	0.681
COVID-19 infection (self)	1.06 (0.60-1.88)	0.841	1.01 (0.52-1.99)	0.968
COVID-19 infection (household)	0.88 (0.51-1.50)	0.637	0.90 (0.47-1.70)	0.737
Positive views on vaccination in general	1.39 (0.88-2.20)	0.158	1.33 (0.74-2.39)	0.336
Positive views on COVID-19 vaccination	1.14 (0.76-1.72)	0.518	1.18 (0.71-1.98)	0.519
Information through traditional media (TV, radio, web)	1.19 (0.73-1.93)	0.494	1.20 (0.69-2.11)	0.515
Information through social media	1.29 (0.85-1.94)	0.234	1.21 (0.75-1.96)	0.427
Information through community network	1.22 (0.76-1.97)	0.409	1.00 (0.58-1.74)	0.998
Information through other source	2.39 (0.57-10.11)	0.236	3.13 (0.70-14.08)	0.137

Factors associated with demand for COVID-19 vaccination

Overall, demand for vaccination was associated with a variety of factors (Table 6). Before adjustment, living in the US and Italy, female gender, older age, comorbidity, perception of being at risk of severe COVID-19, positive views on vaccination including COVID-19 and mentioning traditional media as the main source of information were all associated with more chance to demand the vaccination. On the other hand, living in France and using social media and community networks as the preferred sources of information were negatively associated with demand. After adjustment, increasing age, the presence of co-morbidities, and positive views about vaccination in general and COVID-19 in particular were all significantly associated with increased demand for vaccination, while living in France and relying on community network to get informed were associated with lower demand. Of note, the preference for social media lost its significant negative association with demand after adjustment. Although not statistically significant, there was a trend toward more demand among African migrants.

In Geneva and Baltimore, positive views about vaccines were strongly associated with demand (Appendix). In Paris and Milano, the main predictors were the sources of information. Both social media in Milano and community networks in Paris were negatively associated with demand.

Table 6: Factors associated with demand for COVID-19 vaccination in regression analysis

	Univariate analysis		Multivariate analysis	
	OR (95% CI)	p-value	aOR (95% CI)	p-value
Study site Geneva	Reference		Reference	
Baltimore	2.24 (1.51-3.33)	<0.001	0.97 (0.56-1.68)	0.920
Milan	1.70 (1.14-2.54)	0.009	1.18 (0.66-2.09)	0.578
Paris	0.26 (0.15-0.47)	<0.001	0.15 (0.06-0.38)	<0.001
Gender female	1.43 (1.07-1.92)	0.016	1.23 (0.80-1.88)	0.344
Age (per additional year)	1.04 (1.02-1.05)	<0.001	1.02 (1.00-1.04)	0.019
Region of origin Europe	Reference		Reference	
Africa	0.75 (0.38-1.46)	0.396	2.73 (0.93-8.02)	0.069
Americas	1.62 (0.94-2.80)	0.085	0.85 (0.36-1.96)	0.695
Eastern Mediterranean	0.93 (0.45-1.93)	0.852	1.93 (0.63-5.86)	0.247
South-East Asia	0.38 (0.15-1.01)	0.052	0.45 (0.12-1.65)	0.231
Western Pacific	0.90 (0.46-1.78)	0.769	0.69 (0.26-1.87)	0.467
≥ 1 co-morbidity	1.91 (1.40-2.61)	<0.001	1.77 (1.10-2.84)	0.018
High self-perceived risk of severe COVID-19	1.46 (1.06-2.01)	0.019	1.26 (0.81-1.96)	0.315
COVID-19 infection (self)	1.37 (0.92-2.05)	0.124	1.23 (0.66-2.27)	0.514
COVID-19 infection (household)	1.23 (0.84-1.79)	0.292	0.84 (0.48-1.49)	0.557
Positive views on vaccination (general)	32.5 (14.2-74.4)	<0.001	12.9 (5.17-32.22)	<0.001
Positive views on vaccination (COVID-19)	16.70 (11.2-24.8)	<0.001	9.70 (6.08-15.47)	< 0.001
Information through traditional media (TV, radio, web)	2.25 (1.53-3.29)	<0.001	1.28 (0.75-2.18)	0.360
Information through social media	0.47 (0.35-0.62)	<0.001	0.84 (0.55-1.28)	0.410
Information through community network	0.47 (0.33-0.65)	<0.001	0.61 (0.38-1.00)	0.049
Information through other source	0.30 (0.12-0.73)	0.008	0.44 (0.13-1.43)	0.170
Self-perceived accessibility to COVID-19 Vaccination	1.19 (0.78-1.81)	0.421	1.08 (0.61-1.92)	0.799

Discussion

This study shows that during the early phase of the COVID-19 immunization program in four cities in Europe and the US, most undocumented migrants believed the COVID-19 vaccine would be available to them, but fewer intended to get vaccinated. During this period, participants listed traditional media as the most common source of information, followed by social media and community networks. Although perceptions about vaccination in general were positive, they were much lower for COVID-19 vaccination. We found that factors associated with perceived availability of and demand for COVID-19 vaccination diverged across study sites, reflecting differences in samples, local health policies and cultural preferences. This highlights the importance of collecting data at local level in order to tailor responses. These findings provide insights about the factors underlying vaccine hesitancy among undocumented migrants during the initial phase of the vaccination program and can help strengthen it as currently ongoing as well as inform the early response for future initiatives. Traditional media appears to play an important role at the early stage and positive views about general immunization programs should be leveraged through community engagement and messaging in various languages to address issues of particular concern to undocumented migrants, such as safety of the COVID-19 vaccines, confidentiality, and implications on immigration status.

The high confidence in COVID-19 vaccination access among undocumented migrants is telling given their frequent exclusion from many public health benefits. This is reassuring given the legitimate concern that access to vaccination would be limited for this population. Early in the vaccination roll-out, qualitative research among primarily female migrant farmworkers in the US and migrants with precarious immigration status in the UK showed that misinformation and lack of awareness about entitlements, including access to COVID-19 vaccines, could present substantial barriers to immunization programs.[45,46] In our study, women were more likely to endorse access than men. This could be related to increased familiarity with the vaccination programs and overall health system through the use of reproductive health services and as traditional caregivers for children.[47] Participants thinking vaccine would not be available to them mentioned the lack of registration within the healthcare system as the predominant reason, more than financial, eligibility or practical issues. This may reflect how migrants in precarious legal situation internalize structural barriers restricting their agency to satisfy their essential needs.[48] Of interest, most participants reported hospitals as their preferred place for vaccination. This may reflect concern about vaccine safety requiring specialized care and surveillance and the perception that public hospitals are more accessible and secure regarding the management of personal data than private clinics. Previous studies have indeed shown how migrants used camouflage to avoid detection by immigration authorities and the importance of safe places. [49] The gap between accessibility and demand is concerning. One possible explanation might pertain to the timing of the survey. Indeed, in all study locations, the COVID-19 incidence and death toll had sharply dropped by the beginning of the study which may have lessen the feeling of urgency for vaccination. Additionally, at the same time in all four countries, there were widespread public debates about the mRNA-based vaccines short and long-term safety that may have fueled hesitancy. Indeed, this may contribute to explain the discrepancy between reported confidence in vaccines in general as compared to COVID-19 vaccines in particular. In future studies, longer period of observation may help identify fluctuation on the perception of the risks and therefore of hesitancy associated with epidemiological fluctuations and the adoption by the population of scientific and lay information about new vaccine technologies. In our study, there was regional variability, with the lowest demand among participants from Paris. Information from community networks tended also to be associated with low demand for vaccination and was more common in Paris, highlighting the need for targeted approaches for different communities. In Paris, the level of literacy (though not measured) may have been lower, given that most respondents could not fill in the

questionnaire themselves but had to be helped. This would impact on the potential source of information: information through community networks is more easily accessible in case of language barriers. Also, the second most common source of information was social media, in which content is uncontrolled, opening the debate on how to use social media to harness vaccine hesitancy. Higher demand for vaccination among older people and those with co-morbidities is consistent with global trends and may reflect the risk-benefit calculus for people at higher risk of hospitalization and death from COVID-19. In all four sites, only one quarter to a third of participants reported concern about the risk of a severe infection. These low proportions may be related to the overall young age of participant and likely to the comparable proportion of those reporting suffering multiple chronic infections. Interestingly, high self-perceived risk of COVID-19 or prior COVID-19 infection were not associated with demand for vaccination, perhaps because this includes mild cases of the disease.

Intention to get vaccinated against COVID-19 has evolved over time. The successful implementation of large-scale immunizations programs has encouraged many previously hesitant individuals to get vaccinated, but misinformation and fake news continue to fuel mistrust and slow progress in terms of immunization coverage in many settings. In our study, only two in five individuals reported they would get vaccinated if the COVID-19 vaccine was offered to them. Although comparison with other groups is difficult due to heterogeneity of methods and timing, hesitancy appears to be higher in our sample compared to the general adult population in the countries studied. For example, in a survey conducted in Italy in December 2020, 82% of adults reported willingness to get vaccinated compared to 52% of our study participants from Milan.[50] Similarly, in a survey conducted in France in June 2020, 71.8% of participants reported they would accept vaccination compared to only 14.6% of our Paris participants.[51] An international cross-sectional survey conducted between September 2020 and January 2021, however, showed lower intention to get vaccinated among participants from France (49.2%).[52] Of note, all these surveys were conducted online, with likely bias towards higher educational and socioeconomic status. Specific data on undocumented migrants is very limited, but in a survey conducted in the US in late April 2021, 68% of respondents classified as potentially undocumented reported that they had either been vaccinated or planned to get vaccinated.[53]

This study has several limitations. Participant recruitment was nonrandom and occurred in health facilities serving undocumented migrants, thereby involving a non-representative sample population of neither the health facilities' clients nor undocumented migrants at large, and therefore limiting the generalizability of our findings. Specifically, recruitment in healthcare setting may have biased the perception about vaccine accessibility by selecting people with better ability to navigate the healthcare system. Studies conducted in the community would bring important complementary information to our findings. Moreover, differences in sampling strategies and participants sociodemographic characteristics imply limitations in comparability among locations. Furthermore, the questionnaire was translated in 8 languages and translators were not systematically available during questionnaire administration, hence it is possible that participants speaking a different language had a limited understanding about the questionnaire, thus introducing an information bias and limiting response accuracy. Confidence about access to the COVID-19 vaccine and desire to be vaccinated may differ for undocumented migrants who have not interacted with the health system in their country of residence. Nonetheless, approximately half of respondents in our sample identified lack of health insurance/health card as a major barrier to COVID-19 vaccination. Although concerns about immigration have been shown to dampen healthcare utilization for COVID-19 services among undocumented migrants,[54] we did not specifically ask whether worries about immigration repercussions impacted demand. In our study, public hospitals or clinics were identified as preferred sites for vaccination among those intending to get vaccinated, but we did not collect information about trust in public institutions among vaccine hesitant participants. Finally, for efficiency

purpose, we build the questionnaire using a stringent selection of items previously shown to influence vaccine hesitancy but we cannot claim to cover all areas underlying participants' assessment of the risk-benefit balance for COVID-19 vaccination.

In summary, our study showed a substantial gap between undocumented migrants' perceptions about access to COVID-19 vaccines and demand for vaccination. The World Health Organization, UNICEF, the UN High Commissioner for Refugees, the European Centre for Disease Prevention and Control (ECDC) and the Council of Europe have issued recommendations urging access to COVID-19 vaccination to all vulnerable populations, including low-income countries, undocumented migrants, and refugees.[33] Our results show that building trust and confidence in COVID-19 vaccination is as important as promoting access to tackle hesitancy in this group. Information and promotion of vaccination should particularly focus on men, younger migrants and those with low clinical risks highlighting both individual and collective benefits and reassuring about vaccines safety. Given the marginalization and criminalization of undocumented migrants, this may not be simple and requires tailored local solutions. [55] Women should be seen as potential key partners in trust-building initiatives promoting vaccination. Our data suggests that during the first phase of a new vaccination program as for COVID-19, traditional media is an important source of information and communities need to be engaged to leverage existing confidence in general vaccination programs to reduce hesitancy. Social media play an important role on how migrants balance risks and benefits and could represent an avenue for disseminating objective information and resources. Community engagement is also important to adequately inform and guide community networks, which can be influential but may undermine vaccination efforts unless equipped with official and verified information. Innovative strategies to foster trust in the equitable access to vaccine for everyone and to ensure a high uptake in all groups though multi-pronged tailored intervention may help better controlling the ongoing COVID-19 pandemic. Future research should include the monitoring of hesitancy in this group over longer periods in order to adapt communication strategies and the impact of health promotion interventions using different channels of communication such as social media and community interventions.

Declaration of interest

Authors declare no conflict of interest.

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Authors' statement

YJ: conceptualization, methodology, supervision and writing - review and editing
KP: conceptualization, methodology and writing - original draft
EG: conceptualization, methodology, and writing - review and editing
JC: conceptualization, methodology, and writing - review and editing
MF: data curation, formal analysis and writing - review and editing
AD: data curation and writing - review and editing

SC: investigation and writing - review and editing
GF: investigation and writing - review and editing
RT: investigation and writing - review and editing
SS: investigation and writing - review and editing

Data statement

The dataset that includes all participants' responses to the questionnaire is available at https://doi.org/10.5281/zenodo.5769319.[dataset][56]

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Rapid survey on the intent to be immunized against Covid-19 amongst undocumented migrants

In order to properly meet your health needs, we would like to hear your opinion on the COVID-19 vaccination. This information is anonymous and confidential.

Please tick the correct answer (s) ☒

1. Gender
    a. ☐ Female
    b. ☐ male
2. Age
3. Country of birth
4. Have you suffered from a COVID-19 infection (one choice)
    a. ☐ No
    b. ☐ Yes probably but I haven't been tested
    c. ☐ Yes and I have been tested
5. If yes, when (month/year)?
6. Has somebody living at the same place as you (family or friend) suffered from a COVID-19 infection (one choice)
    a. ☐ No
    b. ☐ Yes probably but she/he hasn't been tested
    c. ☐ Yes and she/he has been tested
7. Do you have any of the following medical conditions that could put you at risk for severe COVID-19 infection (multiple choices)
    a. ☐ High blood pressure (hypertension) or a cardiac (heart) condition
    b. ☐ Diabetes
    c. ☐ Excessive weight
    d. ☐ Chronic disease of the lungs
    e. ☐ Chronic disease of the kidneys
    f. ☐ No
    g. ☐ I don't know
8. What do you think is the risk to your health related to COVID-19 (multiple choices)
    a. ☐ I think the risk is too low to worry
    b. ☐ I follow the recommendations about protection, this is sufficient to be protected
    c. ☐ I don't think I am at risk of a severe infection
    d. ☐ I already got COVID-19 so there is no more risk

e. ☐ I prefer being infected to develop my own immunity
f. ☐ I am worried about developing a severe form of COVID-19
g. ☐ I don't know

9. Do you believe that migrants/persons in your situation will have access to the COVID-19 vaccines here in Switzerland (one choice)
   a. ☐ Yes
   b. ☐ No
   c. ☐ I don't know

10. If no, for what reasons (multiple choices)
   a. ☐ Lack of health insurance
   b. ☐ High cost
   c. ☐ Lack of right to enroll into immunization programs
   d. ☐ Don't know where to go
   e. ☐ Other reason

11. If the vaccine is offered to you, would you like to get immunized against COVID-19 (one choice)
   a. ☐ Yes, no doubt
   b. ☐ Probably yes
   c. ☐ Probably no
   d. ☐ No
   e. ☐ I haven't decided yet

12. If yes, where could you receive the vaccine (multiple choices)
   a. ☐ Hospital (HUG)
   b. ☐ Private doctor
   c. ☐ Pharmacy
   d. ☐ Community organization, charity
   e. ☐ Public health clinic
   f. ☐ Other

13. What is your point of view about vaccines in general (multiple choices)
   a. ☐ I trust in vaccines
   b. ☐ I believe it will protect me
   c. ☐ I am against vaccines in general
   d. ☐ I prefer alternative remedies

e. ☐ I believe I can resist to infections without vaccines

f. ☐ If I have to suffer an infection, vaccine won't help for that

14. What is your point of view about the COVID-19 vaccines (multiple choices)

a. ☐ I trust the COVID-19 vaccine

b. ☐ I believe it will protect me

c. ☐ I don't trust in vaccines using genetic material

d. ☐ I am afraid of negative effects

e. ☐ I think it won't protect me long enough

f. ☐ I don't want to receive two doses

g. ☐ I already had COVID-19 so I don't think I need it

15. How do you access to information about COVID-19 vaccines (multiple choices)

a. ☐ TV, radio, newspapers in Switzerland

b. ☐ TV, radio, newspapers from my country of origin

c. ☐ Websites of the hospital/health authority in Switzerland

d. ☐ Website of the government in Switzerland

e. ☐ Social media (Facebook, YouTube, Instagram, WhatsApp, etc.)

f. ☐ Friends and relatives

g. ☐ Other

Thank you very much for your participation

Appendix

1. Self-perceived accessibility to vaccination

Regression analysis stratified by study site for factors associated with self-perceived accessibility to COVID-19 immunization programs. The univariate and multivariate analysis were repeated by applying a procedure of multiple imputation for missing values (100 imputations).

Geneva (N=441)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	aOR (CI 95%)	p-value
Gender: female	1.36 (0.78-2.35)	0.278	1.20 (0.64-2.27)	0.571
Age (increase by 1 year)	1.01 (0.99-1.04)	0.286	1.01 (0.99-1.04)	0.413
≥1 co-morbidity	1.34 (0.67-2.68)	0.413	1.07 (0.49-2.34)	0.862
High self-perceived risk of COVID-19	0.78 (0.39-1.56)	0.479	1.00 (0.47-2.12)	0.993
COVID-19 infection (self)	1.41 (0.69-2.89)	0.345	0.58 (0.25-1.33)	0.198
COVID-19 infection (household)	1.12 (0.53-2.36)	0.769	1.09 (0.45-2.63)	0.849
Positive views on Immunization (general)	1.66 (0.94-2.94)	0.081	1.68 (0.75-3.78)	0.209
Positive views on Immunization (COVID-19)	1.16 (0.67-2.00)	0.601	0.86 (0.41-1.82)	0.693
Information through traditional media (TV, radio, web)	1.58 (0.86-2.90)	0.137	1.94 (0.95-3.95)	0.069
Information through social media	1.13 (0.65-1.99)	0.664	1.35 (0.70-2.61)	0.377
Information through community network	0.93 (0.49-1.78)	0.837	0.87 (0.43-1.74)	0.689
Information through other source	3.53 (0.47-26.73)	0.222	5.04 (0.62-41.27)	0.132
Region of origin (WHO)				
Europe	Ref.		Ref.	
Africa	1.84 (0.67-5.00)	0.235	1.86 (0.65-5.36)	0.249
Americas	3.17 (1.41-7.15)	0.005	2.68 (1.13-6.35)	0.025
Eastern Mediterranean	3.27 (0.82-13.09)	0.093	2.78 (0.67-11.65)	0.161
Asia	2.09 (0.22-19.86)	0.523	2.61 (0.25-26.82)	0.420
Western Pacific	2.46 (0.97-6.20)	0.057	1.78 (0.65-4.87)	0.260

Baltimore (N=142)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	aOR (CI 95%)	p-value
Gender: female	2.29 (0.93-5.66)	0.072	1.70 (0.60-4.80)	0.317
Age (increase by 1 year)	0.97 (0.93-1.02)	0.239	0.96 (0.91-1.01)	0.105
≥1 co-morbidity	1.37 (0.54-3.43)	0.507	1.96 (0.65-5.84)	0.230
High self-perceived risk of COVID-19	0.70 (0.24-2.03)	0.513	2.69 (0.67-10.75)	0.161
COVID-19 infection (self)	0.63 (0.20-2.00)	0.434	3.31 (0.59-18.61)	0.174
COVID-19 infection (household)	0.87 (0.33-2.32)	0.786	0.72 (0.17-2.96)	0.648
Positive views on Immunization (general)	1.50 (0.28-7.90)	0.635	1.28 (0.20-8.11)	0.794
Positive views on Immunization (COVID-19)	1.46 (0.54-3.90)	0.452	2.12 (0.67-6.65)	0.199
Information through traditional media (TV, radio, web)	0.56 (0.15-2.05)	0.380	0.62 (0.09-4.45)	0.638
Information through social media	2.18 (0.69-6.87)	0.182	2.42 (0.49-11.99)	0.278
Information through community network	0.20 (0.04-1.04)	0.056	0.09 (0.01-0.76)	0.027
Information through other source	NE		NE	
Region of origin (WHO) Europe Africa Americas Eastern Mediterranean Asia Western Pacific	NE		NE	

NE: Odds ratio not estimable due to empty cells or cells with low frequency

Milano (N=126)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	aOR (CI 95%)	p-value
Gender: female	3.65 (1.20 - 11.08)	0.023	2.30 (0.38-13.89)	0.317
Age (increase by 1 year)	1.03 (0.99-1.07)	0.191	0.99 (0.94-1.05)	0.759
≥1 co-morbidity	0.93 (0.31-2.74)	0.893	1.34 (0.25-7.27)	0.734
High self-perceived risk of COVID-19	1.86 (0.62-5.55)	0.266	0.41 (0.09-1.86)	0.247
COVID-19 infection (self)	0.72 (0.09-6.04)	0.761	1.06 (0.06-18.00)	0.965
COVID-19 infection (household)	0.58 (0.15-2.32)	0.441	0.40 (0.05-3.08)	0.376
Positive views on Immunization (general)	0.53 (0.11-2.50)	0.421	1.42 (0.13-15.93)	0.774
Positive views on Immunization (COVID-19)	1.24 (0.40-3.67)	0.730	2.14 (0.37-12.58)	0.398
Information through traditional media (TV, radio, web)	1.28 (0.33-5.00)	0.722	NE	-
Information through social media	0.67 (0.23-1.98)	0.468	0.38 (0.08-1.94)	0.246
Information through community network	1.03 (0.30-3.47)	0.967	2.43 (0.36-16.58)	0.365
Information through other source	0.80 (0.09-7.18)	0.845	0.10 (0.00-2.12)	0.138
Region of origin (WHO)				
Europe	Ref.		Ref.	
Africa	NE	-	NE	-
Americas	0.46 (0.38-0.58)	<0.001	0.53 (0.05-5.92)	0.603
Eastern Mediterranean	0.30 (0.22-0.40)	<0.001	1.27 (0.03-50.44)	0.897
Asia	0.01 (0.01-0.01)	<0.001	NE	-
Western Pacific	NE	-		-

NE: Odds ratio not estimable due to empty cells or cells with low frequency

Paris (N=103)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	aOR (CI 95%)	p-value
Gender: female	1.56 (0.31 -7.98)	0.592	2.93 (0.18-47.09)	0.449
Age (increase by 1 year)	1.03 (0.96-1.11)	0.375	1.09 (0.97-1.24)	0.156
≥1 co-morbidity	1.41 (0.28-7.22)	0.680	0.40 (0.03-6.26)	0.517
High self-perceived risk of COVID-19	0.92 (0.22-3.94)	0.915	0.31 (0.03-3.24)	0.329
COVID-19 infection (self)	NE	-	NE	-
COVID-19 infection (household)	NE	-	NE	-
Positive views on Immunization (general)	2.40 (0.54-10.62)	0.248	15.52 (0.76-316.86)	0.075
Positive views on Immunization (COVID-19)	1.55 (0.37-6.56)	0.554	1.41 (0.11-17.50)	0.788
Information through traditional media (TV, radio, web)	0.53 (0.06-4.49)	0.559	0.15 (0.00-5.14)	0.293
Information through social media	0.99 (0.19-5.14)	0.994	51.34 (1.02-2576.27)	0.049
Information through community network	3.86 (0.96-15.59)	0.058	10.37 (1.25-86.27)	0.030
Information through other source	NE	-	NE	-
Region of origin (WHO)				
Europe	Ref.		Ref.	
Africa	NE	-	4.06 (0.06-11.31)	0.513
Americas	1.00 (0.02-50.40)	1.000	0.03 (0.00-11.31)	0.251
Eastern Mediterranean	13.5 (0.60-305.29)	0.102	15.73 (0.26-936.44)	0.186
Asia	24 (0.79-732.38)	0.068	94.05 (0.54-16348.27)	0.084
Western Pacific	NE	-	NE	-

NE: Odds ratio not estimable due to empty cells or cells with low frequency

2. Demand for COVID-19 vaccination

Regression analysis stratified by study site for factors associated with demand for COVID-19 immunization programs. The univariate and multivariate analysis were repeated by applying a procedure of multiple imputation for missing values (100 imputations).

Geneva (N=441)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	aOR (CI 95%)	p-value
Gender: female	1.08 (0.72-1.62)	0.709	1.23 (0.69-2.18)	0.484
Age (increase by 1 year)	1.03 (1.01-1.05)	0.001	1.02 (1.00-1.05)	0.068
≥1 co-morbidity	1.56 (0.98-2.49)	0.060	1.69 (0.84-3.37)	0.138
High self-perceived risk of COVID-19	1.41 (0.89-2.25)	0.143	1.22 (0.66-2.25)	0.516
COVID-19 infection (self)	1.06 (0.61-1.84)	0.826	0.81 (0.37-1.79)	0.610
COVID-19 infection (household)	1.12 (0.67-1.86)	0.673	1.13 (0.55-2.35)	0.736
Positive views on Immunization (general)	29.26 (11.63-73.60)	<0.001	10.82 (3.81-30.72)	<0.001
Positive views on Immunization (COVID-19)	16.11 (9.60-27.02)	<0.001	8.64 (4.69-15.90)	<0.001
Information through traditional media (TV, radio, web)	1.49 (0.92-2.39)	0.103	0.91 (0.46-1.79)	0.786
Information through social media	0.66 (0.45-0.98)	0.041	0.84 (0.48-1.48)	0.553
Information through community network	0.96 (0.60-1.52)	0.857	0.92 (0.50-1.69)	0.783
Information through other source	0.37 (0.14-1.01)	0.052	0.56 (0.15-2.09)	0.388
Region of origin (WHO)				
Europe	Ref.		Ref.	
Africa	0.98 (0.41-2.35)	0.964	2.16 (0.61-7.71)	0.235
Americas	1.22 (0.60-2.47)	0.586	0.79 (0.29-2.14)	0.641
Eastern Mediterranean	1.74 (0.64-4.69)	0.278	2.09 (0.53-8.33)	0.294
Asia	NE	-	0.59 (0.09-3.78)	0.580
Western Pacific	1.01 (0.46-2.22)	0.987	0.61 (0.20-1.86)	0.385
Self-perceived accessibility to COVID-19 Immunization	1.29 (0.72-2.30)	0.392	1.20 (0.55-2.65)	0.647

NE: Odds ratio not estimable due to empty cells or cells with low frequency

Baltimore (N=142)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	aOR (CI 95%)	p-value
Gender: female	1.23 (0.59-2.60)	0.582	1.75 (0.59-5.20)	0.311
Age (increase by 1 year)	1.07 (1.02-1.11)	0.002	1.03 (0.97-1.09)	0.282
≥1 co-morbidity	2.56 (1.24-5.67)	0.012	2.10 (0.73-6.08)	0.169
High self-perceived risk of COVID-19	0.65 (0.28-1.49)	0.308	1.30 (0.38-4.50)	0.676
COVID-19 infection (self)	0.67 (0.28-1.58)	0.360	2.57 (0.53-12.57)	0.244
COVID-19 infection (household)	0.70 (0.32-1.51)	0.364	0.37 (0.09-1.50)	0.163
Positive views on Immunization (general)	NE	-	NE	-
Positive views on Immunization (COVID-19)	15.63 (5.02-48.63)	<0.001	17.17 (4.74-62.16)	<0.001
Information through traditional media (TV, radio, web)	4.82 (1.82-12.75)	0.002	7.12 (0.83-61.16)	0.074
Information through social media	0.49 (0.22-1.06)	0.069	2.40 (0.34-16.98)	0.381
Information through community network	0.13 (0.01-1.13)	0.064	0.09 (0.00-1.71)	0.108
Information through other source	NE		NE	-
Region of origin (WHO) Europe Africa Americas Eastern Mediterranean Asia Western Pacific	NE	-	NE	-
Self-perceived accessibility to COVID-19 Immunization	1.43 (0.60-3.43)	0.419	1.20 (0.55-2.65)	0.647

NE: Odds ratio not estimable due to empty cells or cells with low frequency

Milano (N=126)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	aOR (CI 95%)	p-value
Gender: female	0.93 (0.44-1.96)	0.842	1.03 (0.17-6.35)	0.978
Age (increase by 1 year)	1.02 (1.00-1.05)	0.100	1.02 (0.97-1.07)	0.509
≥1 co-morbidity	1.30 (0.64-2.63)	0.469	1.51 (0.36-6.39)	0.574
High self-perceived risk of COVID-19	0.73 (0.34-1.55)	0.410	3.09 (0.68-14.01)	0.144
COVID-19 infection (self)	0.38 (0.10-1.50)	0.167	1.44 (0.11-19.19)	0.782
COVID-19 infection (household)	1.36 (0.48-3.84)	0.559	1.37 (0.17-10.75)	0.764
Positive views on Immunization (general)	NE	-	NE	-
Positive views on Immunization (COVID-19)	48.21 (13.36-174.0)	<0.001	NE	-
Information through traditional media (TV, radio, web)	4.42 (1.51-12.97)	0.007	0.08 (0.00-2.22)	0.136
Information through social media	0.44 (0.22-0.91)	0.027	0.11 (0.02-0.48)	0.004
Information through community network	0.76 (0.34-1.66)	0.487	1.83 (0.37-9.12)	0.463
Information through other source	0.14 (0.02-1.19)	0.072	0.35 (0.01-14.84)	0.583
Region of origin (WHO)				
Europe	Ref.		Ref.	
Africa	4.00 (3.34-4.80)	<0.001	NE	-
Americas	1.64 (1.49-1.81)	<0.001	0.57 (0.08-4.27)	0.584
Eastern Mediterranean	1.78 (1.50-2.11)	<0.001	3.02 (0.12-76.35)	0.503
Asia	0.27 (0.21-0.34)	<0.001	0.02 (0.00-4.19)	0.148
Western Pacific	NE	-	NE	-
Self-perceived accessibility to COVID-19 Immunization	1.29 (0.72-2.30)	0.392	1.02 (0.97-1.07)	0.509

NE: Odds ratio not estimable due to empty cells or cells with low frequency

Paris (N=103)

	Univariate analysis		Multivariate analysis	
	OR (CI 95%)	p-value	aOR (CI 95%)	p-value
Gender: female	2.33 (2.09-2.61)	<0.001	2.43 (0.31-19.09)	0.397
Age (increase by 1 year)	1.06 (1.05-1.06)	<0.001	1.08 (0.99-1.18)	0.095
≥1 co-morbidity	3.65 (3.26-4.08)	<0.001	1.63 (0.12-21.77)	0.712
High self-perceived risk of COVID-19	0.30 (0.26-0.33)	<0.001	3.21 (0.36-28.34)	0.294
COVID-19 infection (self)	1.40 (1.13-1.74)	0.002	9.40 (0.36-245.25)	0.178
COVID-19 infection (household)	NE	-	NE	-
Positive views on Immunization (general)	3.65 (0.45-29.65)	0.225	1.33 (0.04-47.30)	0.876
Positive views on Immunization (COVID-19)	3.18 (2.83-3.57)	<0.001	2.70 (0.34-21.30)	0.346
Information through traditional media (TV, radio, web)	NE	-	NE	-
Information through social media	0.51 (0.46-0.58)	<0.001	1.91 (0.20-18.04)	0.574
Information through community network	0.18 (0.16-0.21)	<0.001	0.09 (0.01-0.61)	0.014
Information through other source	NE	-	NE	-
Region of origin (WHO) Europe Africa Americas Eastern Mediterranean Asia Western Pacific	NE	-	NE	-
Self-perceived accessibility to COVID-19 Immunization	0.16 (0.14-0.19)	< 0.001	0.05 (0.00-0.58)	0.017

NE: Odds ratio not estimable due to empty cells or cells with low frequency

Reporting checklist for cross sectional study.

Based on the STROBE cross sectional guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below.

Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation.

Upload your completed checklist as an extra file when you submit to a journal.

In your methods section, say that you used the STROBE cross sectionalreporting guidelines, and cite them as:

von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	#3	State specific objectives, including any prespecified hypotheses	4
Methods			

Study design	#4	Present key elements of study design early in the paper	4
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants.	5
	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	6
Bias	#9	Describe any efforts to address potential sources of bias	5
Study size	#10	Explain how the study size was arrived at	6
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	6
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	6
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	7
Statistical methods	#12c	Explain how missing data were addressed	7
Statistical methods	#12d	If applicable, describe analytical methods taking account of sampling strategy	n/a
Statistical methods	#12e	Describe any sensitivity analyses	7

Results

Participants	#13a	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed. Give information separately for for exposed and unexposed groups if applicable.	7
Participants	#13b	Give reasons for non-participation at each stage	n/a
Participants	#13c	Consider use of a flow diagram	n/a
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	7
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	8
Outcome data	#15	Report numbers of outcome events or summary measures. Give information separately for exposed and unexposed groups if applicable.	8
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	n/a
Main results	#16b	Report category boundaries when continuous variables were categorized	n/a
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	9-12
Discussion			
Key results	#18	Summarise key results with reference to study objectives	12
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	13

Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	13
Generalisability	#21	Discuss the generalisability (external validity) of the study results	13
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	14